PSYCHOLOGY

BY
ROBERT S. WOODWORTH
PROFESSOR OF PSYCHOLOGY
IN COLUMBIA UNIVERSITY

REVISED EDITION

NEW YORK
HENRY HOLT AND COMPANY

PRINTED IN
UNITED STATES OF AMERICA

PREFACE TO THE REVISED EDITION

The first edition of this book aimed, as it said, "to represent the present state of a very active science." So active, in fact, has the science proved itself during the past decade that that first edition already has an old-time atmosphere about it, and the revision, once undertaken, had to be rather drastic. Recent discussions of instinct and heredity call for a more critical handling of those topics. New vistas have opened up in the field of learning. Studies of intelligence have brought to light much of general interest and significance; and so on through the list of topics. While somewhat conservatively inclined, the author certainly believes that psychology is still in the making, and that views and emphases must change with the advance of the science.

More than formerly, it seems, students wish to be shown the evidence for statements made. Nothing could be better, and the author has sought to present his evidence more explicitly than before. No effort has been made to document the book minutely, but occasional footnotes have crept in, citing some of the recent work that has been used in the text.

The new arrangement of the material is frankly an experiment, with somewhat familiar topics, like intelligence and memory, at the beginning, and with the nervous system reserved till near the end, in the hope that it will mean more to the student after he has acquired a stock of psychological knowledge to be tied up with the physiology. If preferred, however, it will be found feasible to lift from the physiological chapter, for earlier treatment, a large section on the nervous system.

Very welcome and valuable assistance in the way of suggestions of new work for inclusion, in the way of criticism, in library work and in proofreading, has been received from many colleagues, Gardner Murphy, Hulsey Cason, Prescott Lecky, Mrs. Enrica Tunnell, Matthew Chappell, G. Richard Wendt, and others, to all of whom, as well as to his publishers for their prodding and their patience alike, the author is deeply grateful.

COLUMBIA UNIVERSITY
August, 1929

R. S. W.

CONTENTS

PSYCHOLOGY

CHAPTER I

WHAT PSYCHOLOGY DOES

THE AIM AND PLAN OF THE STUDY

Modern psychology is an extension of scientific investigation, which has proved so remarkably fruitful in other fields, into a field which at first seems too intricate and baffling for the exact type of work demanded by science. Psychology is a scientific study of the activities of the individual. The most important individual to understand is doubtless the human being, but the study includes animals with advantage, just because their actions are less complex than those of men. Psychology studies the child as well as the adult, and the abnormal as well as the normal adult, for immature activities and disordered activities are often specially illuminating.

Psychology stands between physiology on the one side and social science on the other, since, while they also study human activities, physiology considers the organs that make up the individual, and social science studies groups composed of individuals. Physiology tells of the eye, the brain, the muscles and glands, and their interrelations in the activity of the individual; but psychology takes the individual as a whole, and describes his activities. Social science tells of institutions, ceremonies, customs, and the doings of peoples, while psychology keeps its eyes fixed on the individual playing his part in the group.

The lines between these sciences are like the boundaries between friendly states, and allow of much traffic across the border. Psychology certainly needs to know what is discovered in

the neighboring domains. The human individual talks — that is a psychological fact that can be followed up to an enormous extent without going outside the boundaries of individual study. The child's learning to talk, the uses of speech as an aid to memory and thinking as well as for social communication, the disturbances of speech — all such matters can be studied without asking any questions about the tongue and larynx and the speech centers of the brain; and yet if anyone gets thoroughly interested in the psychology of speech, he wants to know something of the physiology of speech as well; the two studies help each other. On the other side the psychological student would be making a mistake if he overlooked the fact that the child adopts the language, the dialect, the accent of his immediate social group. The individual is born into a certain social environment, with its language, manners and customs, standards of behavior, its houses, furniture, tools — all of which are important in the activities of the individual. An individual without a social environment is as unreal an abstraction as an individual without organs. So psychology likes to be told what is inside the individual, as well as what is outside in the environment; but its own particular job is to see what the individual does; and this is job enough for one science.

"What the individual does" — "the activities of the individual" — these expressions need to be understood broadly and inclusively in order to cover the ground that is allotted to psychology. Speaking or jumping or any sort of movement is obviously an activity; but how about seeing or hearing or feeling happy or sad? Are these anything but passive states of the individual? Let this be our criterion: anything that can occur just the same when life has ceased is not an activity of the individual; but any process that depends on life is to be called activity. Unless you are ready to assert that a dead body sees, hears and feels, you will have to admit that these processes are activities, and include them under the definition of psy-

chology. Some psychologists, true enough, concentrate their studies upon motor activity, and others upon sensory activity; but both sorts, and all other sorts of activity, are included in the science as a whole.

In saying that psychology studies the individual, we do not mean that it is concerned wholly with the differences between one individual and another. This question of individual differences, and their causes, does, indeed, loom large in present-day psychology; but it is by no means the whole of psychology. We want to know also how individuals are alike in their activities. We want the general laws of behavior, of learning, thinking, feeling, moving.

THE TERMINOLOGY OF PSYCHOLOGY

Since psychology studies activities, its terms are properly verbs, and adverbs. It needs one noun, *individual,* or *organism,* or the equivalent, as the subject of all its verbs; and, to be sure, it needs to name any number of objects that act upon the individual or are acted on by him. But the student will soon encounter an assortment of other nouns, names of activities and names of qualities, such as intelligence, memory, imagination, sensation, emotion, consciousness, behavior. All such nouns are properly verbs or adverbs, with " individual " as their subject. Much confusion and controversy would be avoided if these nouns were constantly thought of as verbs.

Instead of " memory," we should say " remembering "; instead of " thought " we should say " thinking," instead of sensation " we should say " seeing, hearing," etc. But, like other learned branches, psychology is prone to transform its verbs into nouns. Then what happens? We forget that our nouns are merely substitutes for verbs, and go hunting for the *things* denoted by the nouns; but there are no such things, there are only the activities that we started with, seeing, remembering, and so on.

Intelligence, consciousness, the unconscious, are by rights not nouns, nor even adjectives or verbs; they are adverbs. The real facts are that the individual acts intelligently — more or less so — acts consciously or unconsciously, as he may also act skillfully, persistently, excitedly. It is a safe rule, then, on encountering any menacing psychological noun, to strip off its linguistic mask, and see what manner of activity lies behind.

THE METHODS OF PSYCHOLOGY

Pursuing its aim of becoming a true science of the individual's activities, psychology nowadays avoids guesswork and armchair theorizing, and goes out to observe the facts. It still theorizes, to be sure; it forms hypotheses as to how people see, think, learn, feel, succeed and fail; but then it tests these hypotheses by finding out whether they agree with facts that can be observed. The hypothesis must be thus verified before it has any standing as a true general statement, or law.

The Experimental Method is preferred as the most trustworthy way of observing the facts, wherever it can be used. To experiment successfully, we must control the conditions under which the individual acts. Sometimes the object is to simplify the conditions, so that the observer can see what is actually taking place. Sometimes the object is to hold conditions constant, so that many individuals can be observed under the same conditions and fairly compared. This is the case in all use of *tests*. Sometimes, again, the object is to vary the conditions systematically, so as to discover which conditions are favorable, and which unfavorable, for a certain activity.

Who shall be the observer in an experiment, the individual whose activities we wish to observe, or some other person watching him? The answer depends on the fact to be observed. If you wish to know whether his heart beats faster when he is excited, you had better feel his pulse. If you want to see how

his breathing is affected by emotion, you had better harness him into a respiration recorder, and get an objective record. If you want to see how quickly he can perform a certain task, you time him with a stop watch or some even more accurate means of measuring time. If you want to see how well he remembers what he has been learning, you ask him to recite it. In all such cases, the individual simply performs, and some one else, either with or without special apparatus, does the observing. But suppose that, while sitting quietly, he solves a problem, and you wish to know the steps he has gone through; then you had better ask him to review his process and make a report. If you want to know whether he likes or dislikes a certain odor, you had better get him to say. There are many such instances in which the individual can observe something of his own activity. This observation by the individual of his own activities is called *introspection,* or "subjective" observation (observation by the "subject," or individual whose activities are being observed), and so distinguished from *objective* observation, which means observation by some other person.

There has been much debate about introspection, some psychologists contending that it is not sufficiently trustworthy for a scientific experiment, but results show that you can depend on it if you do not expect too much from it. In ordinary life, we do not hesitate to employ it. If some one tells you he has the toothache, you assume that he knows. If he tells you that he has started up in a hurry because he just thought of an engagement, you accept his report as a statement of fact. So there is no objection to introspection, in principle, and the only requirement is to use it only under conditions that insure its reasonable reliability. Objective methods are actually more used in psychology.

Psychology is proud of its laboratories, with their apparatus for careful experimentation and measurement. It is proud also of its array of tests for measuring the individual's per-

formance in many directions. It is pleased when its data can be handled by mathematical and statistical methods. Yes, it is rather proud, because its progress in these respects has been rapid within the few decades of its active career. But it knows that it is still a young science, with a long way to go. It still finds it difficult to control the conditions, so as to make exact experiments on many important activities of the individual. So much of our later study will be concerned with various experiments that we need not pause now to give examples of this method.

The genetic method. When a process, such as the child's mental development, must not be interfered with drastically, the requirement of controlling the conditions cannot be fully met, and psychology has to resort to a genetic or follow-up method. The development is observed as it proceeds. When we know that something interesting is going to happen, as that the child is about ready to begin learning to talk, or that he is soon to have a baby brother or sister to whose presence in the family he must adjust himself, then we can be prepared to observe the process step by step.

Often, however, we find that some significant development has occurred that we have not anticipated. We find a genius, or an insane person, a criminal, or a "problem child" before us, and we desire to know how he came to be what he is. Then the best we can do is to adopt a substitute for the genetic method, by reconstructing his history as well as we can from his memory, the memories of his acquaintances, and such records as may have been preserved. This *case history* method has obvious disadvantages, but, as obviously, it is the only way to make a start towards answering certain important questions.

The case history method, up to the present time, has been employed mostly upon individuals whose behavior is abnormal in some respect. Either they have broken down mentally, or

their conduct has become socially objectionable. The object of the case history has been the practical one of helping to remedy the undesirable behavior. Let us consider the case of a boy from a good family who has been caught stealing, and is brought to a clinic, where the staff of experts goes into his entire history from the medical, social and psychological points of view. They win the boy's coöperation by their friendly inquiring spirit. The boy's conduct has not harmed them, and they feel no hostility to him. Rather, their object is to help him by the only sure means, that is, by understanding him. They realize that the misconduct is not mere depravity and maliciousness, but is tied up with difficulties of some sort under which the boy has been struggling, perhaps without anyone's knowledge. They labor to unearth his difficulties, and to trace his misconduct back to its sources in his case history.

However, the clinic does more than construct a history of the case. It examines the boy's present condition by the use of suitable tests, and it proceeds to follow up the case, thus supplementing the case history by a genetic study. Also, the clinic, in coöperation with the home and the school, tries a sort of experiment on the boy, by way of treatment. Any treatment of such a case must needs be experimental in some degree, for one can never be perfectly sure that a given line of treatment will succeed. The case history, along with the boy's present condition, in effect suggests some hypothesis as to the causes of the misconduct; and the experiment consists in testing out this hypothesis by so altering the conditions of the boy's life as to remove the supposed causes. If then the experiment succeeds, the hypothesis is verified; but if not, some other hypothesis must be given a trial. Clinical psychology, then, uses all the methods of psychology; and while it is "applied" rather than "pure" psychology, while, that is to say, it has a practical rather than a purely scientific aim, it may be expected, in proportion as it is adequately carried out, to

throw much light on behavior and development. Still more promising is the real genetic study of young children, now being undertaken with great energy; for the case history is bound to be specially defective in its information on the early years, which may be the most important formative years of the individual's career.

While the cause of misfits and failures is certainly an important matter for study, would it not be still more desirable to trace the development of the successful people, the great people, the lovely people, the splendid people of all sorts? The difficulty is, however, that one cannot tell in advance which little child is going to become that kind of adult. And when a person has already become splendid, and the psychologist suggests that he would make a fine subject for a case history, he may see no advantage to himself and may be impatient with the psychologist's desire to study him for the advancement of science. Adults are rather sensitive about being probed, unless they have got into trouble from which the expert may release them. The result is that, up to date, our case history material is decidedly one-sided. We have to turn to biographies of the great, written usually without special psychological interest, and apt to be very meager in the developmental stage of the individual's life.

However, the thoughtful consideration of anyone's life has some value in an introduction to psychology, as indicating the scope of the science, and the topics demanding attention. So it will not be amiss to introduce here a brief biographical sketch of a successful writer, selected because it is comparatively full on the early years. Gene Stratton-Porter was a successful writer of popular novels, and also of nature studies, essays and poems. Several of her stories were "best sellers" in their day. Whether any of her work will endure as literature we do not pretend to judge. It is enough for our purpose that we find in her an individual of rather notable achievement in

certain lines, whose life is more open to inspection than most. Examining this life history at the very outset of our psychological studies, we certainly shall not expect to draw many conclusions from it. Rather, we shall be looking for problems to follow up in the more intensive studies of the later chapters.

BIOGRAPHICAL SKETCH

Born in 1863, on a prosperous Indiana farm, Gene Stratton was the youngest of twelve children. Her father was a preacher and lecturer as well as a farmer, a self-educated man and a great reader, very fond of natural beauty, and a kind father, though somewhat strict. Among his favorite maxims were: " First be sure you are right, then go ahead," and " Finish whatever you begin." Gene remembered his saying that he would rather see a child of his the author of a book of which he could be proud than sitting on the throne of England.

Gene's mother was petite and dainty, but wonderfully efficient as a mother, housekeeper and entertainer, and specially skillful in raising flowers and plants. Gene later said of her that " she could do more things, and finish them in a greater degree of perfection, than any other woman I have ever known. If I were limited to one adjective in describing her, ' capable ' would be the word." She became an invalid when Gene was five.

As the youngest, Gene was the pet of the family, but she had her little duties to perform, sweeping the walks, feeding the chickens and gathering eggs. She spent most of the day out of doors, especially after her mother became an invalid. She accompanied her father and brothers about the farm, and had her own little garden, where she planted wild flower seeds that she had gathered. She kept butterflies, feeding and watching them for a time and then releasing them. One spring she located sixty-four bird nests, which she visited every day, carrying grain for the seed eaters and worms for the meat eaters. There was one creature called by her parents the " lady bird " that specially aroused her curiosity, as it seemed a peculiar bird, having no nest that could be discovered, and never taking a bath. Sitting quietly for hours in a flower bed, Gene studied the lady birds, and found that they had no tails. Her father admitted that this was queer for a bird. Then she saw that they had no real beak, and that they had four wings; and with these facts she almost convinced her father that

the lady bird was no bird; but her mother insisted that "of course it is a bird." That forced her to attempt to capture one — a difficult task, but finally accomplished — and when careful inspection by the assembled family revealed no feathers, but four wings and six legs, all were forced to admit that the "lady bird" was an insect, and Gene thereafter refused to call it by its popular name.

She learned to read and write at home, but much to her disgust had finally to go to school, and sit indoors all the blessed day with her wild feet imprisoned in shoes and stockings. She early came into conflict with the teacher, who had written on the blackboard the sentence, "Little birds in their nests agree," and was pointing out the good example set by the birds, when Gene, from her intimate knowledge of bird households, interrupted. "Oh, but they *don't* agree. They fight like anything. They pull feathers and peck at each other's eyes till they are all bloody." She got the punishment to be expected. Soon, however, she settled down to diligent school work, and became quite a master of making a finished recitation. About this time, the family moved from the farm to a small town, where Gene kept on her schooling up through the high school. She did not go to college, and always believed that she derived more benefit from studying what she liked in her own way.

An important event in her high school days was the reading of a certain essay before the school assembly. The topic of "Mathematical Law" had been assigned her, but as mathematics was the one subject she hated, she put off, and put off, her writing. Finally, at the last moment, she determined to choose her own subject, and to write an appreciation of a certain piece of fiction which she had loved since childhood, the story of "Picciola," written about the growth of a flower. "At midnight I laid down the pencil and read what I had written. I could make no corrections. I had given my heart's best blood; it came in a tide, and to touch it was sacrilege." When her turn came, the next day in school, she announced that as she knew nothing about the topic assigned her, she had substituted this other topic, and started to read, fully expecting to be halted by a sharp reprimand. Instead, she soon found that she had her audience with her, and her success was so great as to fan into a flame her ever-present ambition to be a writer. So she proceeded to write. She hid in her room at home to write, and behind her books at school; and when the writing-fever was brought to a temporary lull by the danger of school failure, she had two novels and two volumes in verse to store away in her secret file.

For a year or two after finishing school she lived with her family, and had to assert herself strongly to prevent household duties from devolving heavily upon her. She continued to practice writing, submitting her work to the criticism of her father, but making no move towards publication.

Up to the time when she was twenty, though sociably inclined, she had no special favorites among the men. Her own personal romance started during a summer holiday at a near-by lake resort. A man twelve or more years older appeared to wish to make her acquaintance but did not find the opportunity. Shortly afterwards she received a letter from him suggesting that they correspond, to which, after some hesitation, she finally replied, but with the request that he should not continue, "unless you are *certain* you can respect me as *much* as if you had formed my acquaintance in the authorized way." The correspondence flourished, and the next summer the two young writers got acquainted face to face, and were evidently not disappointed in each other. Gene waxed eloquent in some of her love letters: "In the morning of life came the dawn of love; came in my youth, strength and ambition; flooded all the paths of life with the first love of a young, strong, passionate heart."

So, at the age of twenty-two, Gene Stratton became Gene Stratton Porter, and her husband, who had a flourishing small-town business, took her to a comfortable home. Her only child, a daughter, was born a year or two later. Gene proved herself a good mother, as well as an efficient housekeeper, who could make time for some literary work. Her love of outdoors persisted, and at every opportunity she fared afield with her family. She took up photography as an aid in the field studies which she began to make of her beloved birds. As soon as her child was old enough to go to school, she devoted much of her time to illustrated nature studies and submitted them to magazines for publication. Her articles were accepted and paid for, and she became a regular contributor. She put her earnings into high-grade photographic equipment, and was indefatigable in her efforts to secure first-hand observation and photographs of birds and moths, especially of the nesting and young of birds, and of the life history of moths. In all this work, she made no claim to being a scientist. She was a nature lover, and her aim was to bring outdoors vividly to the stay-at-home people and increase the number of nature lovers. This was her mission, her religion.

When she started writing these nature articles, she kept her work

secret even from her family. When her husband discovered what she was about, he became much interested and coöperated loyally. She next tried her hand at a short story and sent it to one of the magazines, carefully concealing this new venture. "I was abnormally sensitive," she later said, "about trying to accomplish anything and failing. I had been taught that it was black disgrace to undertake anything and fail." To forestall the disgrace of having any rejected manuscripts come to the notice of her family, she at this time rented a private post-office box for her own use.

Her short story, however, was accepted, and others were asked for. For about ten years she continued writing nature articles and short stories, before, at the age of forty, she first ventured on a book. This first book was the life story of her favorite bird, the cardinal, interwoven with the doings of some human characters. As the book met with good success, she kept on writing books, and produced about one a year for the rest of her life.

The material for her novels, as for her nature studies, she obtained by first-hand observation. Her old life at home, her father and mother and brothers and sisters, appear in her stories; also people she got to know in her field work, neighbors, employes, and anyone whom she could study till she felt she knew him. "My formula for a book is simplicity itself — an outdoor setting in which I have lived, with the men and women who live there, and their story of joy and sorrow commingled as living among them I know it to be."

A large public enjoyed these stories, but the literary critics found them too sugary. Her reaction to this criticism is interesting. She first insisted that her stories were true to life, though there was a seamy side of life which she knew but did not care to depict. Later, however, she did write one story around the doings of ruthless and immoral men, just to show the critics "that I did know life and that I could tell the truth about the seamy side of it as well as about the pleasant."

All her life she had aspired to be a poet, and when the fever caught her had written verses and hidden them away. Finally she wrote one that she had courage to submit to the judgment of some friendly critics, whose verdict was so favorable that she published this poem, being then fifty-eight years of age; and she put out two or three more within the next few years. She aspired to produce literature of a high order, and believed that in these poems she had done so. At the same time, and in spite of her great success, she was not free from a lurking sense of failure and inferiority.

In these last years, her writing extended to essays and editorials, in which she showed herself a forceful propagandist. Never was her activity greater than at this period. Editorials, poems, novels, nature studies, motion pictures of her stories, public addresses, building two new out-door homes in California, and a voluminous correspondence with readers who wrote to tell her their personal problems, were all in active progress when she was killed in an automobile accident, at the age of sixty-one.

TOPICS FOR LATER STUDY

The story of a person's life impresses us most with the idea of *development,* and raises the problem of the causes that made the individual develop in just this way. The life here presented is remarkable for the continuity of its development. This woman was doing at the age of sixty what she was doing as a little girl, though in the meantime her activity had developed from a childish to a very mature state. The same character traits, such as interest in nature and in people, energy and independence, but with sensitiveness to criticism, appear throughout the story.

Apparently this successful woman owed much to both *heredity* and *environment.* Her parents were energetic and brainy people, and she seems to have " taken after " both of them. They provided her not only with excellent heredity, but with a favorable home environment for fostering love of nature, ambition to write, and zeal to succeed in whatever she undertook. The influences of heredity and of early home environment are so closely interwoven that we cannot possibly separate them, or say how much of her success is due to the one or the other.

Her development looks in part like simple *growing up.* The fact that she fell heartily in love at about the usual time of life might be the result of social custom, or might, as far as we can see, be the result of her having reached maturity. Evidently from the way she writes of " the morning of life and

the dawn of love," falling in love felt to her like growing up and not like following a social convention. There is a question here, but scarcely an answer as yet.

On the other hand, much of her development was certainly the result of *learning*. She studied wild life till she knew it, she studied people, she practiced writing and photography. She never would have obtained her skill and knowledge by simply growing up. So it appears that we shall have two general processes of development to examine.

Our subject was a good observer, rather a remarkable observer, and *observation* is one of the topics we shall want to look into. She certainly knew how to use her eyes and ears, and her attention both to the wild things and to the doings of people was keen and persistent. She was much interested in children's talk, and would take a mental note of their more striking speeches, which were likely to make an appearance later in her stories. She liked to go where she could watch people, so as to notice their ways. How she observed, we can scarcely make out from the record, though there are indications that observation was sharpened by questions which she wanted to answer. We shall have to resort to rather careful experiments in order to study this process of observation.

What she observed, she remembered. She depended on *memory* to furnish materials when needed in her writing. Speeches and maxims stuck in her memory, and so did scenes, form and color, and the behavior of birds and people. The skill developed by practice was retained for later use. Without memory and retention, no permanent benefit would have come from all her observation, practice and learning.

Thinking is another form of activity suggested for our consideration, though it must be confessed that the case history does not reveal it very fully. The same is true of planning and inventing, or *imagination* as we may call it. These processes usually go on behind the scenes, and we see only their

results in questions answered, problems solved, houses designed, stories written. That little incident of the ladybird affords one good instance of thinking accompanied by observation and by active participation.

We find in the case history plenty of evidence that our subject was far from a mere intellectual machine. Her *emotions* were very lively. She felt keenly, she loved strongly, she resented criticism, she was afraid of ridicule, she was jubilant at her successes, she appeared on the whole serenely confident in her powers, yet after all she experienced at times a sense of failure.

In considering a life of intense activity, we are faced with the problem of *motivation.* Granted that our subject had the ability to do what she did, what drove her to do it, instead of settling down into the easy life which was clearly open to her? For one thing, she had from childhood a keen interest in the things that she later wrote about, and also a keen interest in poems and stories and in making them up herself. Her father's influence was very strong, for he, too, was interested in people and in wild life, in beauty of form and color, and in literature. His precept, always to finish what you begin, stayed with her through life, and she used to pride herself, long after he was dead, in the way she was fulfilling his hopes for her. His religious influence had much to do with her "mission" in life. But her mother also, who could do so many things and finish them to perfection, who was such a fine mother and housekeeper, evidently hovered before her as a standard of attainment.

Was she stimulated more by obstacles to be overcome, or by the glow of success? It is hard to say, but we can see both kinds of stimulation present. Being told she couldn't do a certain thing aroused her to go and do it. Being assigned an essay topic of which she knew nothing aroused her, not indeed to work up that disagreeable topic, but to apply herself with

all her energy to writing on a topic of her own choice. On the other hand, the public success of this effort stimulated her very strongly, and just so, later on, the success of each new literary venture roused her to all the greater energy. If she appears to have got through life without many serious obstacles to overcome, the reason is to be sought in her vitality and spontaneous energy, which enabled her to dominate situations, and evidently to dominate everybody about her, in a happy, cheery way that was not resented.

If you notice carefully, you see that in spite of the continuity in her life, of which we spoke at the beginning of these comments, there were changes from time to time in the situation she had to meet, and to each new situation she had to make an *adjustment*. The first new adjustment that we see in the story was necessitated by going to school, and was a difficult adjustment for the little girl. She rebelled against being shut up indoors and against the formality and discipline of the schoolroom. After a time, however, she made a good adjustment, and the way she did it was apparently by getting interested in making a good recitation — a literary success, of a sort. When, as a young woman, she became a housewife, her adjustment was made easy by her genuine love for her husband and by her zeal to excel in this new field of endeavor. A few years later, she began a new adjustment, which she called her emancipation, and which was the adjustment to the life of a housewife who was at the same time an active nature student and writer. Her procedure here was unusual, in that she did not take her family into her confidence till she had secretly made sure of success, when she had a lever to adjust the family situation to her own ambitions. Later, the adjustment of this isolated author to the public world of literary criticism caused her some difficulty, not wholly overcome to the day of her death.

One caution needs to be observed in the use of a case history,

and that is that a single case is not enough to warrant any general conclusions. Suggestions and questions for further study are all we should really extract from a single case. As psychology has learned, from experiments and tests as well as from case histories, a good number of individuals need to be studied before any general conclusions are reached. What seems perfectly clear in one case may not work out at all in other cases. We have given so much space to the case history method in this introduction, not because it is the preferred method in psychology, for it is the least rather than the most preferred, but because it can give us what we want at the outset, a bird's-eye view of the field, with some indication of the topics that are deserving of closer examination.

GENERAL PLAN OF THE BOOK

Now that a number of topics have been suggested for further study, the question of order comes up. Any one of various arrangements would be logical enough, and all the topics are so interconnected that, whichever one we place first, we shall be sure to wish we had the background of the rest. The plan of this book is to start with the broader and less technical topics, and proceed to analysis and still more minute analysis. We start, then, with intelligence and development, proceed next to special forms of activity, push our analysis still further by dipping into physiology to discover what the individual's activities are like, when dissected into the activities of brain, nerves, sense organs, muscles and glands, and finally, after all this analysis, attempt to gather up the threads in a synthetic study of personality.

If the reader has heard of the various schools of present-day psychology — the introspectionists, behaviorists, configurationists, purposivists, psychoanalysts — he may reasonably wish to be informed which school he is being led into by this book. The author's feeling in this matter is that, while all

the schools are good, no one of them is good enough. Each school contains competent psychologists, who are making good contributions to the science, and there is no reason at all why we should not make use of contributions from all sources. On the other hand, when the adherents of any one school begin to exalt their own type of work as the *only* genuine psychology, they become rather ridiculous. The author, then, in common with many other psychologists, professes to belong to no one of the schools. Now if the reader happens to take a fancy to one of the schools, well and good! He can still use a text such as this to furnish him the raw materials for building up his own brand of psychology. Indeed, every reader may well regard the book as raw material, and use some independence in fashioning the final product of his study.

EXERCISES

1. Under each of the following headings, formulate in a single sentence the principal conclusion reached:
   - A. The relation of psychology to other sciences
   - B. The terminology of psychology
   - C. Essentials of the experimental method
   - D. Essentials of the genetic method
   - E. Value of the case history method
   - F. The use of introspection in psychology
   - G. Two processes of mental development
2. Illustrate what is meant by individual differences.
3. Show how a psychological study of manual skill could be supplemented on one side by a physiological study, and on the other side by a social study of the same general topic.
4. What advantages does the genetic method have over the case history method?
5. Suppose, in order to discover whether attendance on a nursery school had any effect on the little child's mental development, you took forty children at the age of just two years and divided them into two groups of twenty, making the groups as nearly equal in home environment and apparent intelligence as possible, then had one group attend nursery school for two years and the other not, and finally

examined both groups to see whether one had advanced farther than the other — would you call this (1) an experimental study or a genetic study; (2) an introspective or an objective study?

6. Which of these nouns are properly verbs and which adverbs?

attention	imagination
perception	anger
emotion	character
stupidity	speech
truthfulness	pleasure
behavior	fickleness
accuracy	mind
curiosity	strength
sorrow	introspection
knowledge	industry

7. In the case history given above, what signs of an independent spirit do you find, and what signs of diffidence?

8. In the same case history, what indications of the subject's intelligence or stupidity do you find?

9. Analyze the "lady bird" incident, to show evidences of the rôles played by the subject's father and mother in stimulating her intellectual development.

10. If you were to step to the blackboard and solve a problem in algebra, which elements of your activity could best be observed introspectively, and which objectively?

REFERENCES

Some books which will be of service for additional light on each successive chapter are the following:

E. S. Robinson and F. R. Robinson, *Readings in General Psychology,* 1923. This is a collection of brief extracts from many authors, brought together under topics.

G. M. Whipple, *Manual of Mental and Physical Tests,* 2 vols., 1914–1915. Here we find not only a description of test methods in all kinds of performances, but also a summary of results obtained.

R. S. Ellis, *The Psychology of Individual Differences,* 1928. This book also covers a wide field of different activities, considered from the point of view of how individuals differ.

G. Murphy, *An Historical Introduction to Modern Psychology,* 1929. This book, covering principally the recent history, reveals much of the evidence on different topics, along with the discussions of disputed questions that have led to our present views.

On the genetic method, see H. L. Hollingworth, *Mental Growth and Decline,* 1927.

On modern methods of obtaining case histories, see W. Healy, A. F. Bronner, E. M. H. Baylor, and J. P. Murphy, 1929.

CHAPTER II

INTELLIGENCE

THE INTELLIGENCE TESTS AND THEIR RESULTS, WITH SOME ATTEMPT AT ANALYSIS OF INTELLIGENCE

We are living in a period of emphasis on intelligence. Where formerly a man's strength and courage, a woman's beauty and charm, were most in honor, nowadays intelligence is singled out for mention. Strength, beauty, charm and courage are perhaps no less admired than formerly — and indeed more and more is being said of the importance of "personality" — but more and more is being said of intelligence as well. This change in emphasis does not mean that mankind is more intelligent than in earlier days, though it may mean that modern conditions of life make heavier demands on intelligence. The science of psychology has been practically forced by public demand to devote a large share of its energies in the last few decades to the study of intelligence.

Intelligence is thought of as a general characteristic of the individual, and one individual is said to be more intelligent than another. This form of expression is likely to mislead us into conceiving of intelligence as a sort of substance of which one individual possesses more than another. In reality, intelligence is a term akin to strength or speed, denoting a characteristic of action; and as actions are most directly expressed by verbs, these characteristics of action are properly adverbs. The concrete fact is that one individual pulls more strongly, or moves more rapidly, or acts more intelligently, than another. To say that man possesses more intelligence than the dog

really means that man acts more intelligently than the dog. If, then, we could tell what we mean by saying that man acts more intelligently than the dog, we should have a preliminary definition of intelligence.

Several differences between human and canine behavior suggest themselves.

1. Man makes more use of his past experience.

2. On the other hand, man adapts himself better to novel situations.

3. Man takes account in his actions of a broader situation than the dog can fathom. He doesn't grab a chop from the butcher's counter and scuttle with it into the alley, but takes account of the facts that it is the butcher's chop, and that something out of sight in the ice box may be better anyway.

We reach the same conception of intelligence if we turn our question about and ask what stupidity is, or what it means to act stupidly. A stupid person has to be shown over and over again; when, however, he has once learned a certain way of acting, he continues acting in the same way even when the situation has so changed that some other action would be better; and he is apt to act without taking account of all the facts of the case.

So we reach a preliminary definition of intelligence as acting according to the situation in hand, with use of what has been learned before, but also with due regard to what is novel in the present situation, and to the whole situation rather than to some striking part of it.

INDIVIDUAL DIFFERENCES IN INTELLIGENCE

The recent extensive work on intelligence has been largely inspired by an interest in individual differences. It is an easy observation to make that some persons are much brighter, and others much more stupid, than the average person. Though the genius would be the more fascinating, and really the more

important, individual to understand, actual scientific and humanitarian work began with the feeble-minded. It was about the year 1800 that careful study began to be made of them, in the hope that suitable methods of education would bring them up to normal intelligence. This hope, to be sure, has never been realized, though they can be taught much of value to them, provided their limitations are recognized and they are treated accordingly.

It was soon found that not all mentally defective individuals were equal in intelligence. The most defective were called *idiots,* the next in order *imbeciles,* and the least defective were called simply feeble-minded, or, more recently, *morons*. The degree of intelligence represented by each of these terms can be gathered from the following descriptions.

The intelligence of idiots is to be described mostly in negative terms. They do not learn even to avoid the common dangers of life, but will put their hands into the fire, walk heedlessly into deep water, or remain in the way of a motor car. They cannot learn to wash and dress themselves, and the lowest of them cannot even learn to eat or drink or take care of other bodily needs. They do not learn to talk, beyond a few monosyllables.

Imbeciles are distinguished from idiots by the fact that they do learn to avoid the common dangers of life. But they cannot learn much in the way of useful work, the lowest imbeciles being incapable of any work, those somewhat higher in the scale learning to perform a few useful acts under constant supervision, and those near the upper limit of the imbecile class learning to dress, wash and feed themselves under supervision, and to help scrub the floors, etc. But they cannot be trusted to perform any but the simplest and briefest tasks without constant direction.

Morons, like imbeciles and idiots, are not all equal among themselves in intelligence, and the least intelligent morons are

scarcely to be distinguished from the highest imbeciles. But morons can be trusted to perform simple routine tasks without constant supervision. In an institution, they make the beds, run errands, and some of the "high-grade morons" become skillful in taking care of animals, or in tending the babies, or in carpenter work, or in operating a lathe or sewing machine. Some progressive institutions for the feeble-minded have had considerable success in releasing the high-grade morons of stable character for remunerative employment in the community; but much then depends upon a general supervision of their lives by some one who understands their limitations and has their welfare at heart. Without such a guardian, the morons are likely to make poor use of their leisure time, and to spend their money foolishly; the girls are easily led into prostitution, and the boys into thievery. In general, they do not handle a broad or novel situation successfully.

The legal definition of feeble-minded persons (or morons) adopted in Great Britain after a careful study is worth quoting. The feeble-minded are

> Persons in whose case there exists from birth or from an early age mental defectiveness not amounting to imbecility, yet so pronounced that they require care, supervision, and control for their own protection or for the protection of others, or, in the case of children, that they, by reason of such defectiveness, appear to be permanently incapable of receiving proper benefit from the instruction in ordinary schools.

It will be noted that the moron adult is here distinguished from the person of normal intelligence by his inability to maintain himself in the social environment, the definition being couched in social rather than intellectual terms. In the case of children, however, the definition points to the inability of the feeble-minded to master the abstract subjects of the regular school curriculum.

THE BINET TESTS

Such was the state of knowledge about the year 1900, when the school authorities of the city of Paris became disturbed at the great number of children who were backward in their school work, though not so stupid as to appear definitely feeble-minded. The question whether this backwardness was due to inattention and mischievousness, as the teachers were apt to suppose, or to insufficient mentality, was placed in the hands of Alfred Binet, a leading psychologist of the day.

Binet set to work to devise a scale for measuring degrees of intelligence as objectively as possible. His task was to devise a reliable *test* for intelligence. Now tests of various sorts were already in existence. Galton, who in 1884 established in London an Anthropometric Laboratory for the measurement of individuals and the study of heredity and environment, had supplemented his anatomical measurements, his strength tests, his tests of sight and hearing, by a series of mental tests; he and others, especially Cattell, had devised tests for a variety of separate mental performances; and the use of these tests had established the fundamental fact that even normal individuals differed widely from one another in every performance tried. But what Binet required was a comprehensive measure of an individual's general intelligence.

After some experimenting, Binet concluded that no single performance could be used as a fair indicator of intelligence. It was necessary to give the person tested plenty of chances to show how much use he made of past experience, and how well he dealt with a novel situation. Binet's test series therefore consisted of a large number of little tests, each of which could be scored as passed or failed, so that counting up the number of successes gave the subject's total score. The separate tests needed to be graded in difficulty from very easy to very hard,

so as to measure all degrees of intelligence; and just here Binet had the brilliant idea of utilizing the known fact that children increase in intelligence as they grow up. His easiest tests were just within the reach of three-year-olds, the next easiest beyond the average three-year-old and just within the reach of four-year-olds; and so on up the age scale. As he could not tell by inspection the age level of a given test, he had to try each test out on children of different ages, and often to make a given test a little easier or harder to fit it for the age level where it was needed. Years of experimentation, and several revisions, were needed before the Binet scale became a fairly accurate measuring instrument for the intelligence of children, and Binet himself died, in 1911, before his task was fully completed.

Binet's tests were soon adapted to use in various countries. Terman, in the United States, improved the tests in detail, and carried the scale up to the adult level, while Kuhlmann extended the scale downward to the age level of a year and less. A few samples from the Kuhlmann and Terman revisions will give some idea of the character of the Binet tests. There are usually six varied tests at each age level.

3-months level: Carrying the hand to the mouth by a definite rather than merely by a random movement.

6-months level: Reaching for a small bright object dangled before the child within his reach.

12-months level: Imitating a movement such as shaking a rattle or ringing a small bell.

2-year level: Removing the paper wrapping from a piece of candy before putting the candy into the mouth.

3-year level: Naming familiar objects — the child to pass the test must name at least three out of five familiar objects that are shown him.

6-year level: Finding omissions in pictures of faces, from which the nose, or one eye, etc., is left out. Four such pictures

are shown, and three correct responses are required to pass the test.

8-year level: Tell how wood and coal are alike; and so with three other pairs of familiar things; two correct responses required to pass the test.

12-year level: Vocabulary test — rough definitions showing understanding of 40 words out of a standard list of 100.

14-year level: Telling the three main differences between a president and a king.

The question may be raised, "Why such arbitrary standards — three out of four required here, two out of four there, forty out of a hundred in another test?" The answer is that the standards are not really arbitrary, but are fixed so as to agree with what the average child of a given age actually does with the tests.

Special training, in addition to the right way with children, is necessary for the psychological examiner who wishes to use these tests. Unless the examiner can secure the child's interest and effort, while still giving the tests in the standardized manner and scoring each answer in the standardized way, the tests will give false results. The Binet scale is one of the psychologist's instruments of precision, and the novice must learn the technique of it from the expert.

Scoring of the Binet Tests. With each separate test scored as passed or failed, the individual's total "raw score" is simply the number of tests passed. Older children make larger scores, on the average, than younger children, and the average score increases regularly from year to year during childhood and early youth. For each age, then, there is a *norm* or average score, and any raw score is the norm for some age. So, any raw score can be translated into an age equivalent, which is called the *mental age*. A person who makes a certain score is said to have the equivalent mental age. So, any person, no matter

what his chronological age, whose score in the tests is equal to the norm for $8\frac{1}{2}$ years, is said to have a mental age of $8\frac{1}{2}$ years. More precisely, he is said to have a " Binet test age " of $8\frac{1}{2}$ years. Other tests, different in content from the Binet, can be scored in terms of mental age or test age, provided they have yielded a progressive series of age norms. In general, then, mental age is a measure of mental development, obtained by seeing what age norm the individual reaches in the given type of performance. Binet's invention of this graphic, if somewhat indirect, way of stating the results of his tests has had much to do with their widespread use.

The Intelligence Quotient. Evidently a child's mental age, alone, does not tell how bright he is. A child with a mental age of 8 years is a dull child if his chronological age is 12 years, but a bright child if his chronological age is 5 years. The mental age and the chronological age need to be considered together. A convenient way of putting them together is to divide the mental age by the chronological age, and thus obtain what is called the Intelligence Quotient, or IQ. Our child with a mental age of 8 years and a chronological age of 12 years has an IQ of 8/12 or .67, while the other child with the same mental age but a chronological age of only 5 years has the much higher IQ of 8/5, or 1.6. The exactly average child has a mental age equal to his chronological age, and his IQ is therefore 1.00.

It is customary to express the IQ in percent. Thus the exactly average child, of any age, is said to have an IQ of 100; an IQ of 70 lies far below the average, and one of 130 far above the average.

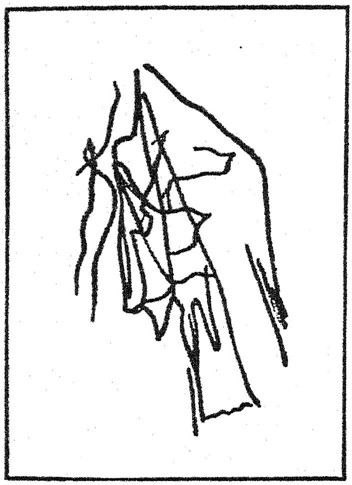
OTHER FORMS OF INTELLIGENCE TESTS

While the Binet tests are given orally to one individual at a time, making use of spoken language, and calling for knowledge picked up in the child's experience out of school, rather than

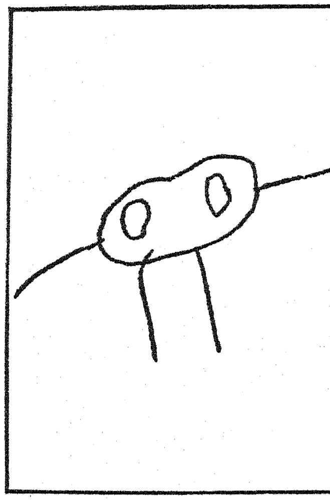
for school knowledge, other tests are in use differing from the Binet in one or another of these respects. There are " achievement tests " in the different school subjects, designed to give an objective measure of the child's mastery of arithmetic, reading, etc., and there are " trade " tests to measure an artisan's mastery of his trade. Achievement and trade tests measure the special knowledge derived from special training, while intelligence tests are based upon the general experience of life.

Performance tests are intelligence tests which, as compared with the Binet, make little use of oral question and answer, and more use of concrete materials. They are specially needed for testing anyone with a language handicap, due often to insufficient acquaintance with the language spoken in the testing. Some persons, even without any language handicap, do better when dealing with concrete objects than when answering questions about objects which are only spoken of and not actually present. The " form board " is a good example of a performance test. Blocks of different shapes are to be fitted into corresponding holes in a board; the time of performance is measured, and count is kept also of the errors, consisting in trying to put a block into a differently shaped hole. To the average adult, this task is too simple to serve as a test of intelligence, but the young child finds it difficult, and the adult of low mental age goes at it in the same haphazard way as the young child, trying to force the square block into the round hole. He does not pin himself down to the one essential requirement of matching blocks and holes according to their shape.

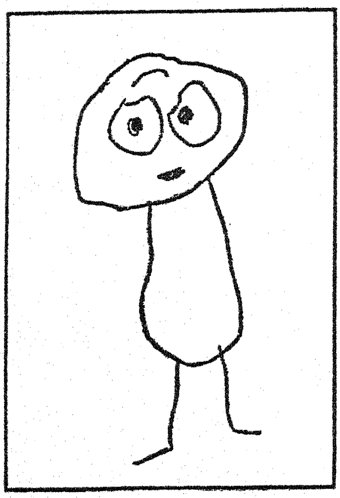
A picture drawing test has been found good for the younger ages, from four to ten. The child is simply asked to " make a man, the best man he can make," with pencil on paper. The test is scored not for the esthetic value of the child's effort, but for the completeness and coherence of the drawing. Like all



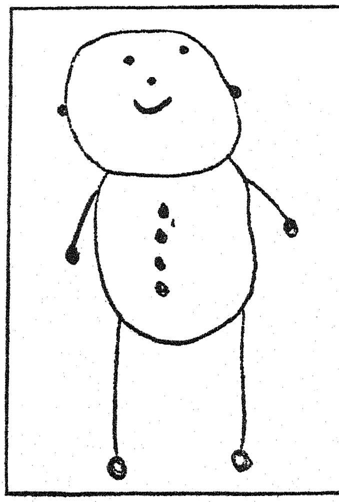
A



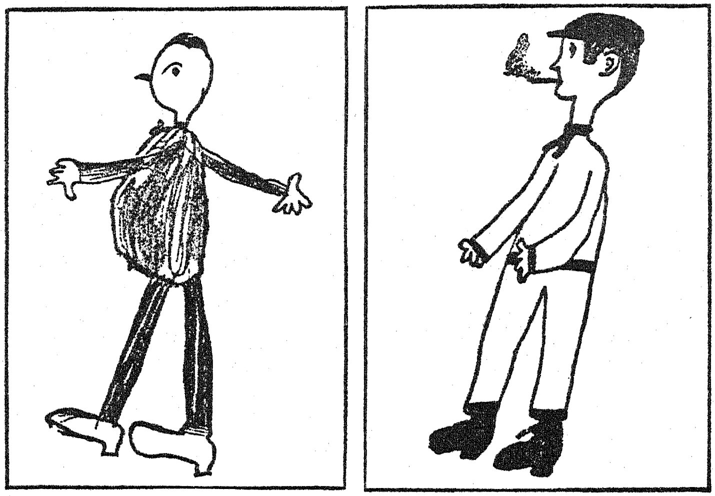
B



C



D



E F

FIG. 1. — Children's drawings of a man, from F. L. Goodenough, *Measurement of Intelligence by Drawings*, 1926.

A. Score 0, M.A. (mental age), less than 3 years.

B. Score 4 points, for head, legs, arms, eyes; M.A., 4 years.

C. Score 8 points, for head, legs, trunk, trunk longer than wide, eyes, pupils of eyes, mouth, forehead; M.A., 5 years.

D. Score 14 points, for head, legs, arms, trunk, trunk longer than wide, arms and legs attached to trunk, eyes, nose, mouth, ears, hands, legs in fair proportion to trunk, some clothing, firm and well-controlled lines; M.A., 6 years, 6 months.

E. Score 26 points, including most of those mentioned above, and in addition: shoulders, neck, neck continuous with head, hair, clothing non-transparent, fingers, thumbs, arms and legs shown in two dimensions, heels, head in fair proportion, eyebrow; M.A., 9 years, 6 months.

F. Score 44 points, including most of those mentioned above, and in addition: lips, nostrils, elbow, knee, projecting chin, profile, eye detail (4 points), ears in correct position and proportion, arms attached at right point, hair non-transparent and well shown, good proportion of head, arms, legs and feet, good lines and motor control (3 points), costume complete without incongruities (5 points): M.A., 13 years or over.

performance tests, this one had to be standardized by examining the actual performance of many children at each age. The advance with age consists partly in the inclusion of more items in the picture, partly in putting the items in better relation to each other (as in attaching the arms to the trunk rather than to the head, as younger children do), and partly in representing the man as he could be seen at one time (not combining two eyes with a profile, nor showing the legs through the trousers). A child whose performance is on a level with that of the average five-year-old has a mental age (man-drawing age) of five years.

Another good performance test is the "picture completion." A picture is shown with square holes cut out, the cut-out pieces also being presented, mixed with other squares of the same size, which have irrelevant objects pictured on them. The child has to select from the whole collection of square pieces the one which belongs in each hole in the picture. The better his understanding of the picture, the better his selection.

Yet another style of performance test is provided by a maze on paper, through which the shortest path has to be followed with a pencil. In order to prevent the pencil from straying into a promising blind alley, the maze has to be examined as a whole and not attacked blindly and impulsively.

Group tests are given to a number of individuals at once, just as is done in ordinary school examinations. Economy of time is the primary consideration in their use, but it is also true that some persons do better in a group than when under the direct eye of the examiner; so that a combination of individual and group tests is desirable. A common procedure in a large testing program is to start with a group test, and follow up by individual tests of those who score very low or very high in the group test.

The first extensive use of group tests was made in the Ameri-

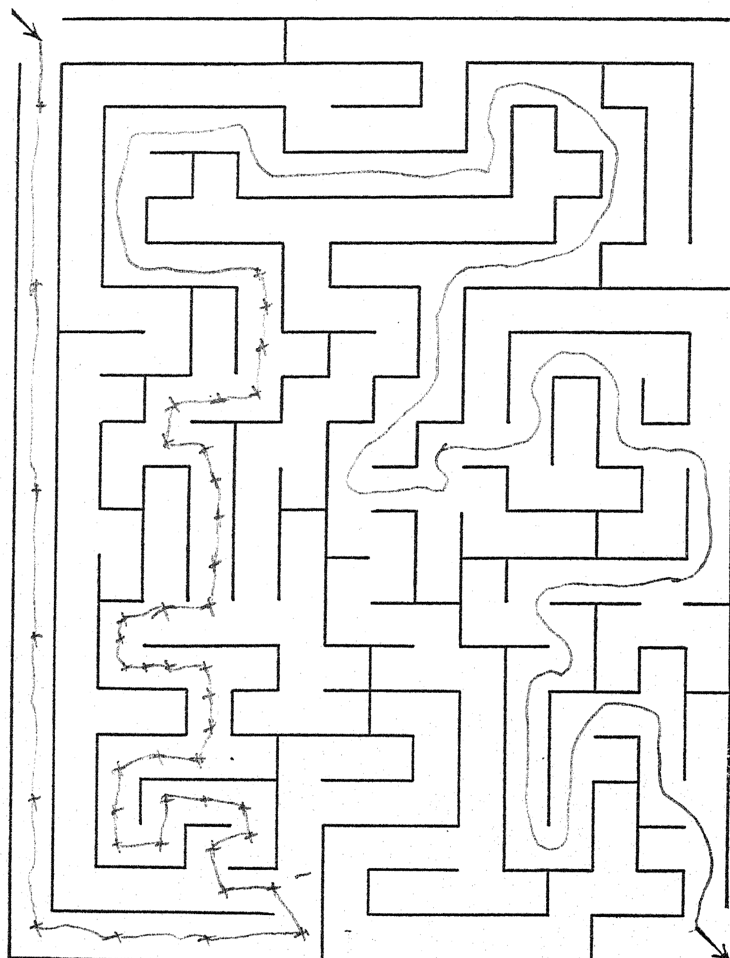


FIG. 2.—A maze. Draw a continuous line, following the most direct path from the entrance to the exit; no erasures allowed.

can Army during the World War, for the purpose of detecting both the dull recruit who was scarcely capable of learning the duties of a soldier, and the bright individual who could learn the duties of an officer. The Army Alpha was a test for those

who could read English, and the Army Beta a test for illiterates and foreigners. Among the types of problems included in Alpha were: a page of arithmetical problems, ranging from extremely simple ones at the top to more complex (though non-technical) ones at the bottom; a page calling for distinguishing between synonyms and opposites; a page calling for bits of information, more or less familiar; a page of disarranged sentences (as, " wet rain always is," " school horses all to go," " first in murder is self-defence in killing the degree "), to be put straight mentally and then checked as true or false; and a page calling for the selection of the best of three reasons offered for a given fact, as, for example, " Why is copper used for electric wires? Because — it is mined in Montana — it is a good conductor — it is the cheapest metal." In the Army Beta, which was conducted by pantomime and blackboard illustration, with practically no use of even oral speech, there were pictures to be completed by drawing in a missing part; mazes; rows of symbols with repetition of a pattern which was to be continued, as in the two lines below.

OXOXO
XOXOOXXOXO

THE DISTRIBUTION OF INTELLIGENCE IN THE POPULATION

The first result of the work with intelligence tests is that individuals formerly classed together as simply normal or average do differ considerably among themselves. About 60 percent of all children have an IQ between 90 and 110, and so differ little from the exact average, while 20 percent are below 90, and 20 percent above 110. The following table gives the distribution in somewhat greater detail:

IQ below 70	1% of all children
IQ 70–79	5%
IQ 80–89	14%

IQ 90–99	30%	of all children
IQ 100–109	30%	
IQ 110–119	14%	
IQ 120–129	5%	
IQ above 129	1%	

This distribution can be pictured in the form of a distribution curve. See Fig. 3.

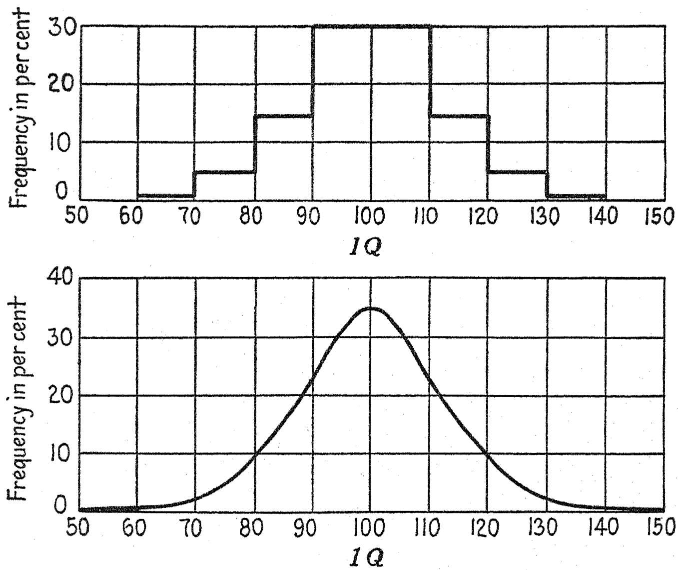


Fig. 3.—The frequency in the population of different values of IQ, represented in graphic form. The upper graph shows the frequency of each step of ten points, while the lower graph shows the same distribution in steps so small as to give a continuous curve. The smooth curve is the well-known "distribution curve."

When a child has been tested and his IQ determined, this bare number is sometimes translated into more descriptive terms, and he is then called:

an idiot if his IQ is below 25
an imbecile if his IQ is 25–50
a moron if his IQ is 50–70
a borderline case if his IQ is 70–80
dull if his IQ is 80–90
(roughly) average if his IQ is 90–110
superior if his IQ is 110–120
very superior if his IQ is 120–140
a genius or near-genius if his IQ is above 140

But this latter procedure has no scientific merit, for at the best it is simply giving up our finer scale of measurement for a coarser one; and the coarser scale, especially with its descriptive names, has several disadvantages:

1. It obscures the important fact that intelligence grades off by imperceptible degrees from one extreme to the other, and not by large jumps.

2. It sometimes leads to large errors in assigning the intelligence grade of an individual. We have to expect slight errors in the use of such a measuring instrument as the intelligence tests; sometimes the examiner makes a slip, sometimes the subject is in poor condition, sometimes a subject may happen to have had special experience in the line of one or more of the tests. Now an error of as much as 5 points in IQ does not misrepresent the subject's level seriously. But suppose such an error leaves a subject's IQ just below 70 when it should have been just above 70, and we then class him as a moron instead of a borderline case; the error is large and serious.

3. The use in this connection of the descriptive terms, "genius," "moron," etc., is especially unscientific and misleading, because these terms imply more than can be shown by intelligence tests alone. "Genius" implies some special ability in literature, art, science, or what not, in addition to the general or all-round intelligence measured by the tests.

Similarly, to dub a person a "moron" implies that he is unable to maintain himself in the social environment without special assistance. But whether an individual shall maintain himself in the community or not depends on his health and emotional stability, and on the environment he has to meet, as well as on his intelligence.

In view of these considerations, it is a pity to cheapen the scientific, even though partial, measure of the individual accomplished by the intelligence tests by translating the numerical results into descriptive terms. The real fact, brought out by the tests, is the continuous gradation of intelligence from the high to the low extreme, with no gaps anywhere, no distinct classes. The continuous gradation found in intelligence, with many individuals clustering close to the average, and fewer and fewer the further from the average in either direction, is the same sort of distribution that is found for such physical measurements as height and weight. One important result of the intelligence tests, then, is the proof that such continuous gradation is the fact in mental as well as in physical characteristics.

CONSTANCY OF THE INTELLIGENCE QUOTIENT

Since the mental age of the exactly average child is by definition equal to his chronological age, and since the IQ is the ratio of these two, it follows that the average IQ is the same for all ages, namely 100. But it is quite a different question whether the individual child maintains a constant IQ as he grows older. One child's IQ might rise, and another's decline; and this is the fact to some extent, but to a surprisingly slight extent. In general, the individual child's IQ remains almost the same from year to year, so that a fairly accurate prediction can be made, from the outcome of a test at the age of five or six, as to what the subject's mental age is going to be when he is ten or twelve years old, or even older.

Here, for example, is the record of a little girl, tested five times over a period of six years:

	Chronological Age		*Mental Age*		IQ
First test	6 years	8 mos.	5 years	6 mos.	83
Second test	7	1	5	4	75
Third test	8	2	6	10	84
Fourth test	8	7	7	0	81
Fifth test	12	10	9	10	77

She varies from 80 by only a few points, up or down. Here is the record of another little girl, of about average intelligence:

	Chronological Age		*Mental Age*		IQ
First test	6 years	6 mos.	6 years	10 mos.	105
Second test	7	2	6	10	95
Third test	8	3	8	10	107
Fourth test	9	6	9	7	101
Fifth test	12	8	13	1	103

And here is a third girl, of high intelligence:

	Chronological Age		*Mental Age*		IQ
First test	4 years	9 mos.	6 mos.	8 years	140
Second test	7	4	10	4	141
Third test	10	9	13	1	140

It must be admitted, however, that this last child is unusually constant; so we had better add another case with very high intelligence.

	Chronological Age		*Mental Age*		IQ
First test	5 years	3 mos.	9 years	3 mos.	179
Second test	6	2	9	5	153
Third test	11	5	16	4	143

This last girl does show a considerable drop from her original extremely high level, and yet she still remains well within the upper one percent of all children. Moreover, her mental age at the last test was up in the region where the tests are still far from complete and accurate.

But these are individual cases, which might easily be picked out to give the impression either of constancy or of inconstancy. Retests of many hundreds of children, brought together from several sources, show on the average a change from the first IQ of about 5 points up or down, while a change of as much as 10 points appears in only 10–15% of all the cases. Moreover the changes which do appear are usually haphazard rather than progressively upward or downward.

A definite and permanent rise in IQ is found, however, after relief from such a handicap as partial deafness or blindness. The stimulus of a first-class school seems to have an appreciable though slight effect. In two very stimulating schools, which receive scarcely any children with an IQ of under 100, the gain in IQ from the time of entrance at the age of 5–8 years to the retest about four years later amounted on the average to 6 points. The accompanying diagram shows what happened in the cases of twenty-five of these children, each of whom had an IQ of 115 on entrance. Some moved down, more moved up, and the changes are somewhat greater than those usually reported, yet they are all small in comparison with the whole range of common IQ values.

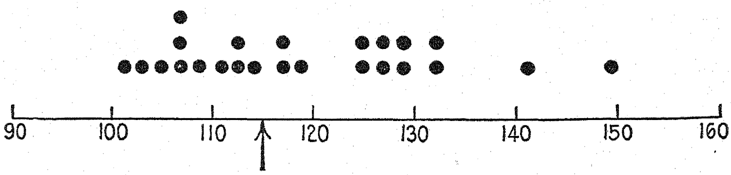


FIG. 4. — Twenty-five children, whose IQ was 115 when first tested at the age of five to eight years, were re-tested 3–5 years later, with a scattering result as shown, each child's later IQ being represented by a dot.

The Intelligence Quotient, then, while not fixed beyond all possibility of change, is something characteristic of the individual. What that something is can be seen on comparing the IQ and the Mental Age. Mental Age tells the extent of the individual's mental development up to a certain time, Chronological Age tells how long it has taken him to reach that extent of development, and the quotient of the two, the IQ, therefore tells the *rate of mental development,* the speed with which it has progressed.

Suppose two children test alike, with a Mental Age of 9 years. Their development, along the lines covered by the tests, is equal. But suppose one of these children is twelve years old, and the other six. The younger child has reached the nine-year level in half the time of the older child, and has thus advanced twice as fast. Thus the bright child, with few exceptions, becomes the intelligent adult. From the IQ of the child we can predict, with some accuracy, the level of intelligence which he will reach as an adult. To make this prediction, however, we need to know how long mental development continues.

HOW LONG INTELLIGENCE CONTINUES TO DEVELOP

During childhood and early youth, the score in the intelligence tests increases year by year. But how long does this development continue? Is intelligence like muscular strength which increases on into the twenties, or like hearing which shows some falling off even before twenty? It is difficult to answer this question, first because of the difficulty of devising adequate tests for adult intelligence, and second because of the difficulty of finding a representative sample of the adult population for the purpose of establishing age norms.

If you attempt to devise tests suited for adults, you are baffled by the varying occupations and conditions of adults, and can scarcely find a common fund of experience beyond the child's level. Since one element in intelligent behavior is the

use of past experience, the lack of a common fund of experience, at the adult level, makes it very difficult to find suitable test materials.

Fair sampling of the population, for testing purposes, is almost impossible after the age at which children begin to leave school and go to work. Before that age, the school population affords a fair sample; but after that age, it is almost impossible to assemble a sample that shall fairly represent the whole population.

The result is that we do not certainly know, as yet, whether or not intelligence increases beyond the age of fourteen. The big sample (though not necessarily a fair sample) of the adult male population tested in the American Army during the World War gave an average score on a level with thirteen-year-olds. Other samples have indicated a rise of intelligence up to fifteen or sixteen. Efforts have been made to follow mental development up through the 'teens by repeated testing of the same

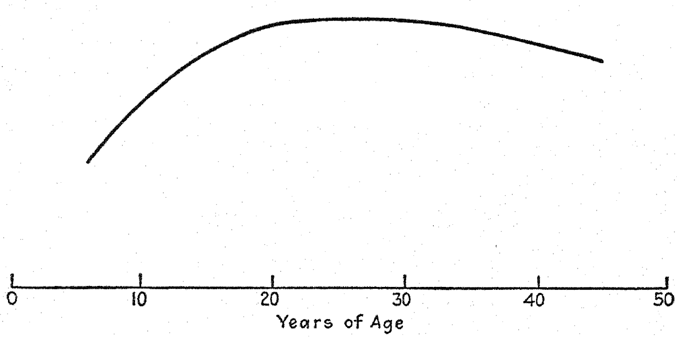


FIG. 5.— (From E. L. Thorndike, *Adult Learning*, 1928). The age curve of learning ability. The curve rises in the early years, indicating the growing ability of the individual to learn new material, and declines slowly from a maximum in the twenties.

individuals. Some studies of this sort have failed to find any advance beyond 14 years, while others have shown a continued, though slow improvement up to 18 or even 20. Learn-

ing ability, which is certainly akin to intelligence, has been found to be greater from 15 to 20 than earlier, and to decline very little if at all before twenty-five, and then but slowly till the age of 45 at least. The learning ability at 45 averages from ten to twenty percent less than at the age of twenty.

If, then, intelligence and learning power reach their maximum at 15–20, does this mean that the individual then ceases to learn and improve? How absurd! It means that he has just reached the age when he can learn most rapidly, and improve most rapidly in his chosen line of activity. It is an advantage, rather than the reverse, that the young person should reach nearly his full intellectual power early in his teens. The improvement which certainly occurs from that age on for ten, twenty, thirty or even more years means simply that the individual has been making good use of his fully developed powers. He has been learning, acquiring knowledge and skill. He has been meeting a variety of novel situations, occupational, social, personal, and has made intelligent adjustments to them. So he has become a bigger and better individual, though his sheer power of learning and meeting new requirements was fully developed at the beginning of the period.

Reverting for a moment to the matter of predicting the adult level of intelligence from the IQ in childhood, we now see that we can predict, with some margin of error, that a child whose IQ is 50 will reach, as an adult, the mental level of the average child of seven or eight, and that a child whose IQ is 75 will reach the mental level of the average child of ten or twelve. Since mental age ceases to have its proper meaning after the age of full development of intelligence, we cannot make our prediction in the same terms for the superior child, but we can say that a child whose IQ is 135, and who belongs therefore in the upper one percent of children, will probably be found in or near to the upper one percent of adults, in

respect to his intelligence. Whether his achievement as an adult shall entitle him to an equally high rating depends not only on his intelligence, but also on the use he makes of his intelligence.

THE HIGHER INTELLIGENCE OF HIGHER OCCUPATIONAL CLASSES

Occupations which demand much mental activity, provided they are well paid, attract individuals of high intelligence. So we should expect, and the expectation is partially supported by the facts. The tests of recruits in the Army showed that, on the average, professional men ranked highest, bookkeepers and clerks rather high, mechanics fairly well, and other occupations in order, with unskilled laborers at the bottom. Such was the *average* result, but it was equally noticeable that the *spread* of intelligence, for almost every occupation, was very wide. Some professional men, for instance, did not rank high, and some laborers did rank high, and the most intelligent of the laborers surpassed the least intelligent of the professional men.

A man's occupation cannot be the cause of his high or low intelligence, since the adult intelligence level of the individual is usually reached and established before he enters on his occupation. Rather, a man's intelligence level is a factor in his selection of an occupation. But there must be other influential factors, otherwise we should not find the wide spread of intelligence level within each occupation. As things go now, without much scientific control or advice, many men are misfits in the occupation which they select.

But how about the *children* of the men of different occupations? This is really a more significant question, and the answer is that the children, in general, show the same occupational gradation as their parents, the children of professional men ranking highest, the children of common laborers lowest. An adjoining table shows the results obtained in several localities. The table shows the averages only, and we must remem-

ber, here again, that there is a wide spread of IQ among the children of each occupational group. The table shows that the average IQ of children of professional fathers is 112 to 116 in different localities, and, at the other extreme, that the average IQ of children of common laborers is 89 to 96 in different localities, with other occupations showing intermediate averages.

INTELLIGENCE QUOTIENT AVERAGES OF CHILDREN WHOSE FATHERS ARE IN DIFFERENT OCCUPATIONAL GROUPS

Locality	*Northumberland, England*	*An Ohio industrial town*	*Rural New York State*	*Small town and irrigation district in Wyoming*
No. children tested	13,419	4,727	6,688	360
Average IQ of all children tested	100	103	96	102
Children of professional men	112	115	116	115
Managers	110	113	107	
Clerks	110	112		
Salesmen and shopkeepers	106	109		103
Foremen	103	106	109	
Skilled and semi-skilled workmen	100	102	97	111
Common laborers	96	94	89	95
Agriculture, all grades	98	100	91	100

The Northumberland data are from Duff and Thomson, *British Journal of Psychology,* 1923, vol. 14, pp. 192–198; the Ohio data from J. E. Collins, *Journal of Educational Research,* 1928, vol. 17, pp. 157–169; the rural New York data from Haggerty and Nash, *Journal of Educational Psychology,* 1924, vol. 15, pp. 559–572; and the Wyoming data from E. S. Mustor, in an unpublished thesis in the Columbia University Library, dated 1926.

Now why should children differ in intelligence according to the occupation of their fathers? Here more than one explanation is possible. One explanation is based on environment, another on heredity.

According to the environmental explanation, the children of professional people, for example, growing up in better circumstances and in more intellectual homes than the children of laborers, are more stimulated to intelligent behavior from early childhood on, and consequently develop more rapidly and completely in this respect.

According to the explanation by heredity, the children of the abler parents get their better start, not in early childhood, not even in the cradle, but before birth, in their superior native constitutions. The abler fathers secure the better occupations, but they have the better children by force of heredity and not by virtue of the superior home environment which they are able to provide for their children.

We could debate over these alternatives for a month, each one of us taking the side that appealed to him, without reaching any agreement. The parents who provide the better heredity for their children provide the better environment as well, so that heredity and environment work together and cannot be separated. The stupid parents give their children a poor start in heredity, and follow up this poor start by a dull, unstimulating environment. No wonder their children are stupid; but how far the heredity is responsible and how far the environment, we cannot see, when each child grows up in his own home.

It is worth while asking, however, *how early* in childhood the differences between occupational groups begin to appear. The results quoted in the preceding table are from children of school age. Below is another table, showing the results obtained in Minneapolis from pre-school children, two to four years of age. The occupations are classified a little differently, but in gen-

eral the same gradation according to father's occupation is found in these little children as in the older ones in the preceding table. If the difference is due to environment, environment must get in its work very early indeed.

INTELLIGENCE QUOTIENT AVERAGES OF VERY YOUNG CHILDREN WHOSE FATHERS ARE IN DIFFERENT OCCUPATIONAL GROUPS

Occupational group (Barr rating)	*Number of children tested*	*Average IQ*
I. Professional men	56	116
II. Managers and proprietors	29	112
III. Clerks, salesmen, retailers, mechanics	129	108
IV. Farmers, bakers, painters, chauffeurs, barbers, waiters, etc.	79	105
V. Semi-skilled factory operatives, teamsters, porters, servants	48	104
VI. Laborers	39	96
All together	380	107

These data are from F. L. Goodenough, *The Kuhlman-Binet Tests for Children of Preschool Age,* 1928, pp. 45–49.

INTELLIGENCE OF FOSTER CHILDREN

Foster children are of great scientific interest, just because their home environment does not correspond to their heredity. Usually their heredity is not above average, while their foster homes are distinctly above average. The question then is whether they grow up with intelligence corresponding to their heredity, or corresponding to their home environment.

Foster children turn out, on the whole, encouragingly well,

both in intelligence and in behavior; but they do not usually come up to the level of their foster parents. Their achievement lies between the moderate level to be expected from their heredity and the high level to be expected from their foster home environment.

The best foster children to study are those adopted very soon after birth, so that their whole childhood is spent in the superior environment of their foster homes; for it may be that the first few years of a child's life have the most effect on his intelligence and character. Children who come into the hands of child-placing agencies soon after birth are usually the children of unmarried mothers, who feel compelled to let their babies go at the earliest possible moment. Unfortunately for our purpose, little can sometimes be learned regarding the fathers of these children, but some are known to be of rather low intelligence, and some of good intelligence, some of low occupational level and some of high; and a fair prediction from the parentage would give these children an average IQ of not far from 100. Now these babies are adopted into foster homes of higher occupational class, from which we can predict an average IQ of about 115. That is to say, own children from these same homes, or from homes matched with them, have an average IQ of 115. How do the foster children in these superior homes turn out in intelligence, when tested late in childhood? Do they equal the own children of such superior homes, or do they remain at the level of 100 predicted for them from their heredity?

Two large samples of such children, taken into superior foster homes within the first year of life, have been tested, one sample in Chicago and the other in California. The IQ of the Chicago sample in later childhood averaged 104, and that of the California group averaged 107. The two studies, made by different investigators, are thus in good agreement, and lead to something like the following tentative conclusion:

Average heredity plus average environment gives an IQ of 100,
Somewhat superior heredity and environment give an IQ of 115,
Average heredity plus somewhat superior environment gives an IQ of 104–107.

The weak point in this argument is our uncertainty regarding the heredity of these children; if it were lower than estimated, then environment had a greater effect than appears in the figures; but if it were just a little higher than estimated, then environment had no effect at all on intelligence. The only *sure* conclusions are that foster children really do well in the environment of a superior home, but that they do not fully measure up, in intelligence, to the level of their superior environment. Much debate on the question of heredity and environment is still to be expected, and much more evidence is required before the debaters can be brought to agreement. The study of foster children is just at its beginning, and later work will doubtless yield more exact knowledge on the relative importance of heredity and environment in producing the differences which exist among people in intelligence and personality.[1]

INTELLIGENCE OF STUDENTS

The little children of six years and thereabouts, who assemble each year to begin their schooling, are of all degrees of intelligence except the lowest. They present almost a true picture of the general population as regards the distribution of IQ. Some of these children find school work easy and make rapid progress, " skipping a grade " once or twice in the next few years. Others make slow progress and have to repeat

[1] References on foster children: S. Van S. Theis, *How Foster Children Turn Out*, 1924. Freeman, Holzinger and Mitchell, in *Twenty-seventh Yearbook of the National Society for the Study of Education*, 1928, pp. 102–217. B. S. Burks, same *Yearbook*, 1928, pp. 219–316.

grades; and the bulk of the children are strung out between these extremes of school progress.

There is rather a close correspondence between the child's IQ and his ability to succeed in school. The child's school progress can be fairly well predicted from his standing in an intelligence test. The correspondence between intelligence and school achievement is especially close when each child is given an opportunity to advance at his own rate.

An interesting experiment on this matter was tried in the public schools of New York City. Two classes were formed of children eight years old, twenty children in each class, and all of high intelligence, but one class consisted of children with IQ from 152 to 183, averaging 165, and the other class ran twenty points lower, averaging 146. The home environments were excellent, and averaged the same for the two groups. The question was whether, among children of superior environment, and all really of decidedly high intelligence, the difference of twenty points in IQ would make any difference in school progress. The experiment continued for three years, each child being allowed to proceed at his own rate, under the supervision of excellent teachers. The result was that, while all these children advanced in their studies much more rapidly than the average school child, still the class with the higher IQ made considerably more progress than the other class. The upper group were definitely superior in such complicated work as the understanding of connected passages, the addition of fractions, nature study and science, whereas the two groups were about equal in simpler work such as ordinary addition.[2]

Children who enter the high school are a selected group in respect to intelligence, because those with low IQ have not been able to progress so far up the educational ladder; and the youth who graduate from the high school are a still more

[2] L. S. Hollingworth and M. V. Cobb, *Twenty-seventh Yearbook of the National Society for the Study of Education*, 1928, part II, pp. 3–34.

select group. The colleges try to limit the freshman class to those of superior ability, and succeed to such an extent that intelligence tests of freshmen show them to represent a very high selection from the general population.

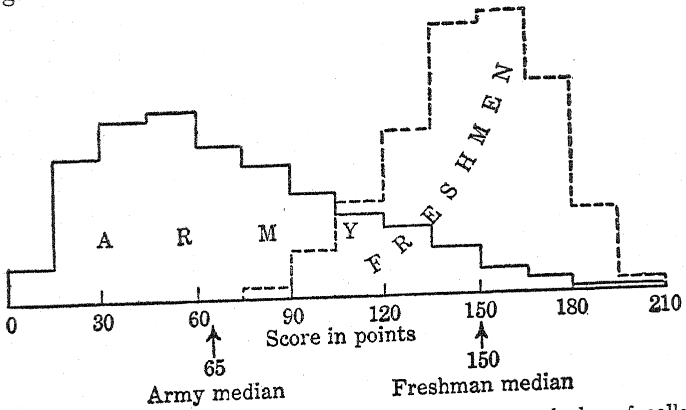


FIG. 6. — Distribution of the scores of drafted men, and also of college freshmen, in the Alpha test. The height of the broken line above the base line is made proportional to the percent of the group that made the score indicated just below along the base line.

But the correspondence between intelligence and academic achievement is not by any means so close in college as it is in the primary and secondary schools. The reason is, in part, that the college group is so highly selected that moderate success in college work is within the ability of nearly all college students who will do the work; and in part the reason is the well-known fact that some who are well able do not choose to work. Their energies may not be released at this period of their lives, or, if released, may be directed into extra-curricular channels; in short, alongside of the question of ability we have the question of motivation.

INTELLIGENCE RATING OF THE GREAT MEN OF HISTORY

Sufficient time has not yet elapsed, since the invention of intelligence tests, to follow through life the careers of children

who test so high as to be called youthful geniuses. Whether the rare child with an IQ of over 150 is likely to distinguish himself by his achievements in adult life — or if not, why not — we must leave to the future to decide. The great men of the past were not tested, but sometimes an estimate of their IQ in childhood can be made on the basis of their recorded performances. When we find Ralph Waldo Emerson composing a long poem at the age of ten, of which the following lines are a sample,

> "Six score and twenty thousand 'gan the fray,
> Six score alone survived that dreadful day,"

we say that the performance is beyond his years, and that his mental age must have exceeded his chronological age, and his IQ have been over 100. From this and similar evidence, he has been estimated to have had an IQ of roughly 145. Since, unfortunately, only scanty records remain of the childhood of many great men, our best estimate of their IQ is often little better than a guess. But, whenever the record is at all adequate, the indicated IQ is always over 100, and usually over 120.

As we read the early stories of great men, we are struck by other qualities besides intelligence, which must have been important in their active careers — such qualities as persistence of effort, confidence in their own powers, force of character, and ambition or the desire to excel. While all eminent men have shown high intelligence, the most eminent have not necessarily had the highest intelligence. Napoleon, by his energy and aggressiveness, combined with intelligence, made such a mark in the world — or such a dent in it — that he is still rated as the most famous man in history; yet the IQ of 135 indicated by his record in childhood is much surpassed by that of lesser men, as Macaulay and John Stuart Mill, with estimated IQ in childhood of 180 to 190.

The writers and thinkers seem from the showing to have been more brilliant youngsters than the doers of various sorts. The reason may be in part that early performances of an artistic or practical sort are not given sufficient weight in our tests and estimates. Achievement in music or painting seems to depend on special aptitudes somewhat distinct from intelligence, since there are certainly very intelligent persons who have no gifts at all in these artistic directions.[3]

THE INTELLIGENCE OF DIFFERENT RACES

In view of the very unequal cultural achievements of different races and nations — in inventions, science, art, literature, and social organization — it is easy to jump to the conclusion that the races differ in native intelligence. Most people believe in the mental inequality of races, each nation, however, being convinced of its own superiority, so that the common belief of mankind does not help us here towards a scientific conclusion. It indicates race prejudice rather than a dispassioned view of the facts. The facts of the matter are really very complex. No race or nation ever creates its own civilization from the ground up, but the greatest nations have been the greatest borrowers. Even the ancient Greeks, as creative as any nation of history, derived their alphabet from the Phoenicians and the beginnings of their art from the Egyptians. Without performing the impossible task of separating the creative achievements of a race from its borrowings, we cannot use the civilization or "culture" of a race as an index of its native intelligence.

The children of any nation are born into a certain culture, which those children did not create, but which they adopt as their own. They adopt its language, customs, industries, its mode of living, its mode of thinking, its beliefs and ideals.

[3] The estimates of juvenile intelligence of men of history are from Cox, in Vol. II of Terman's *Genetic Studies of Genius,* 1926.

They become attached to the ways of their own people, and suspicious and contemptuous of foreign ways and foreign peoples. When the American Indians and the white settlers came into contact, the white man quickly adopted, to be sure, the Indian's corn, potatoes and tobacco, and the Indian the white man's fire arms, horses and whisky, but in the main each race shunned the other's culture. Neither adopted the other's ways of thinking and acting. Even today, when we should like to compare Whites and Indians by the use of intelligence tests, we are baffled by the lack of a fund of common experience to supply the materials for fair comparative tests.

Here are the results we get if we do, nevertheless, apply such tests as we have to Indians. Sitting side by side in rural and small-town public schools of the state of Oklahoma were about 300 full-blood Indians, about 300 mixed-blood (white-Indian crossing), and about 400 white children. They were in grades four to eight. They took a group intelligence test, with the following average results, in terms of IQ.

Full-blood Indian children,	average	IQ	73
Mixed-blood children,	"	"	91
White children	"	"	100

As usual, the individuals of each group scattered widely, but on the average, as the figures show, the Indian children made a poorer score than the white children; and it appears significant that the children of mixed blood fell between the full-blood Indian and white. It looks like the effect of blood or race. At the same time, we can be practically certain that the white man's tests do not meet the Indian on the Indian's own cultural ground, and also that the mixed-blood children have more of the white man's cultural background than do the full-blood Indian children. So we have to discount the results of the tests somewhat, but how much we do not know.[4]

[4] These data are from Garth and Garrett, in *School and Society*, 1928, vol. 27, p. 182.

Negro children in the South have given an average IQ of about 75, though a sample in the city of Nashville gave 85, which is about the average obtained from Negro children in Northern cities. The geographical difference may be due to differences of schooling and other environmental factors, but is just as likely to be the effect of selective migration, the Negro families that migrate being presumably more alert and intelligent than those who remain in their country homes. The relatively low standing of most Negro children in the intelligence tests may be due to race, to unstimulating early environment, or to inadequacies in the tests. There is no sure decision, as yet, between these several possibilities.

It is, however, important to notice that Chinese and Japanese children, tested in California, British Columbia and Hawaii, obtain an average IQ of just about 100, being thus on a par with white children; from which we learn that the white man's tests do not give a low standing to *every* alien group.

Children born in America of immigrant European parents, and tested in American public schools, differ according to the nation from which their parents came. Here are the averages obtained in factory towns in Massachusetts:

Children of	Swedish	parents,	average	IQ	102
"	" English	"	"	"	101
"	" Jewish	"	"	"	100
"	" German	"	"	"	99
"	" American	"	"	"	98
"	" Lithuanian	"	"	"	97
"	" Irish	"	"	"	96
"	" Slavic	"	"	"	90
"	" Greek	"	"	"	88
"	" Italian	"	"	"	86
"	" French Canadian	"	"	"	85
"	" Portugese	"	"	"	83

Similar results have been obtained elsewhere. The results must certainly not be accepted as revealing differences between the *nations* from which these immigrants came; for the factor of migrational selection accounts for some of the differences observed in this country. The Swedes and English probably came from higher occupational classes in their home countries, and in search of higher jobs here, than the Italians and Portuguese. Though the immigrant groups differ, we cannot conclude that the nations of Europe differ, from the evidence in hand.

The language handicap, always a source of danger in comparative tests of nations and races, would seem to be avoided altogether by the "man-drawing test," referred to on page 31. Here are the IQ averages obtained by the use of this test on young children in California:[5]

Children	of	Jewish	parents,	average	IQ	106
"	"	Scandinavian	"	"	"	105
"	"	Chinese	"	"	"	103
"	"	American	"	"	"	100
"	"	Japanese	"	"	"	100
"	"	German	"	"	"	99
"	"	Armenian	"	"	"	92
"	"	Italian	"	"	"	88
"	"	Mexican	"	"	"	87
"	"	Indian	"	"	"	86
"	"	Negro	"	"	"	83

The results of the different investigations agree closely, and give prima facie evidence of differences in intelligence between different parentage groups. We must look this evidence squarely in the face, but without race prejudice, and always bearing in

[5] The Massachusetts data are from N. D. M. Hirsch, *Genetic Psychology Monographs,* 1926, vol. 1, nos. 3–4; the California data are from F. L. Goodenough, *Journal of Experimental Psychology,* 1926, vol. 9, p. 394.

mind the two sources of error already mentioned: the sampling error, and the error of unfair tests. The samples that we find in a country like the United States, coming from Italy, Scandinavia, China, may not fairly and equally represent the home populations of these countries; and so the error of sampling may creep into our studies of race differences. The tests we have so far prepared may conform better to the cultural background of one immigrant group than to another, and unfairness may thus creep in.

Thus it is that in the face of all the evidence at hand on the question of racial differences in intelligence, the doctors disagree badly. Some authorities conclude that the races and nations really do differ in native intelligence; other equally important authorities, while admitting that individuals and families differ in native intelligence, hold that all races are potentially equal; and still other equally important authorities go so far as to deny native differences even between families and individuals, preferring to believe that all individuals are potentially equal, and that all differences are the result of environmental influences, such as disease and malnutrition on the negative side, home training and education on the positive. What can we do, when the doctors thus disagree? The best course, having got the problem before us, is to suspend judgment and keep our eyes open from year to year for fresh and more conclusive evidence that will probably be discovered.

INTELLIGENCE AND CONDUCT

Intelligence, such as is measured by the intelligence tests, is an asset in most lines of activity. It is an asset in the student's study, and also on the football field. It is an asset in the lawyer's office, in the mechanic's shop, and on the farm. It is an asset in maintaining one's health, and in getting on well with people. It is, to be sure, more important in some lines of activity than in others — more important, for instance, in

office work than in salesmanship. But about the only way in which a person's intelligence works against him is when his occupation is not up to his intelligence level, so that he becomes dissatisfied, heedless and mischievous. A boy may be a disturbing element in a schoolroom because his mental age is above the school grade in which he is placed. It does not pay employers to pick intelligent employees for dull, monotonous jobs; such employees on such jobs are apt not to work well or stick long.

On the other hand, one whose intelligence is not up to the work required of him is constantly humiliated by failure, and is likely to become sullen and rebellious. A dull, big boy in a school grade too high for his mental age finds it much pleasanter out of school, and by drifting into habitual truancy may make a start towards conduct forbidden by the community, in short towards delinquency. It appears that some criminal careers begin in just this way, and in such cases we can speak of low intelligence as a factor in antisocial conduct. But notice that it is not low intelligence by itself that produces the delinquency, but low intelligence combined with social demands (as school demands) that are unsuited to the individual's ability. When the school, perhaps by the introduction of shop work, furnishes a chance for this particular boy to succeed, his history is apt to be very different.

Since the invention of the tests, much attention has been paid to the intelligence of criminals and especially of young delinquents. The early studies seemed to show that a majority of delinquents were feeble-minded, but with the improvement of test methods—and with better social provision for the mentally defective—the test results have changed somewhat. It now appears that, though the average intelligence of delinquents is rather low, only a small fraction can be called feeble-minded. Some are average and a few rather high in intelligence, but the typical delinquent has an IQ of about 80 or 85. He is dull and obtuse rather than bright and keen. The facts

of the matter would be better stated if turned around to read as follows: Feeble-minded young persons are very apt to get into trouble, except where society makes suitable provision for their training and supervision; and young persons of dull, though not really defective intelligence are also somewhat likely to get into trouble, and need more attention than they now receive from the community; but the young person of average or even high intelligence is not thereby immune to social maladjustment and misconduct. On the whole, intelligence is an important social asset.

The difficult problem of the causation of misconduct needs to be studied in a comprehensive way, with the different factors brought together into the picture. It is important to consider the delinquent's emotional make-up as well as his intelligence, and at the same time to consider his environment, especially his home environment. Poor emotional adjustment and poor treatment and discipline at home appear to be fully as important as low intelligence, and these factors often operate together. An adolescent girl, badly managed at home, may drift into sexual misconduct, especially if of low intelligence, which handicaps her economically and socially and makes it difficult for her to solve her own problems. The same considerations apply to stealing, the commonest form of delinquency among boys.[6]

Thus, though intelligence is an asset in life, it does not by any means include all the assets, nor does lack of intelligence cover all the deficiencies of one's equipment for life. The emotions need to be considered, the health and energy of the individual, his persistence, poise, sociability, and many characteristics which go to make up his "personality." As we proceed with our explorations, we shall come across facts related to character and personality, and at the end we can attempt to sum up our knowledge.

[6] C. L. Burt, *The Young Delinquent,* 1925.

AN ANALYSIS OF INTELLIGENCE

Since psychologists measure intelligence, you would expect them to know what intelligence is, but as a matter of fact they are much more ready with their tests than with their definition. This seems absurd, yet we must remember that we all measure weight, while the definition of what weight really is is a hard problem for advanced physics. So the problem of what intelligence is, or, better, what is the real difference between behaving more and less intelligently, is a difficult problem, on which psychologists are not yet in agreement.

We started the chapter with a rough analysis, based on a comparison of man and the dog, man being admittedly the more intelligent of the two; and the comparison showed us the use of past experience, adjustment to the novelty of the present situation, and adjustment to the breadth of the present situation, as characteristics of intelligence.

How else than by this comparative method shall we proceed in our attempt to analyze intelligence? Suppose we look closely at the tests which do measure intelligence, and ask what they demand of the individual who succeeds in passing them. The first thing that strikes the eye is the variety of the tests. One gets the impression that intelligence must consist simply in doing a miscellaneous lot of things and doing them well. However, we soon notice that many of the test elements depend on past experience, on the ability to learn and remember. But they do not usually call for mere memory, but rather for applying what has been learned to a novel problem. So far, the tests bear us out in our preliminary analysis.

Many of the tests, also, call for a certain breadth. Removing the paper wrapping before putting the candy in the mouth is a rudimentary instance, suited to the normal breadth of a two-year-old. Drawing the head, trunk, arms and legs of a man in the right relations and proportions is an instance at a

higher level. Completing a picture so that the insert shall fit the picture as a whole, tracing a path through the maze without impulsively dashing into the blind alleys, getting all the words of a disarranged sentence into their proper places — such tasks demand some breadth of view, some ability to discern the pattern of the whole situation, or, we might put it, some seeing of relationships. Many other test elements, such as the arithmetical problems, or telling how certain objects are alike or different, also call for this ability to deal with patterns and relationships; and some psychologists hold that we have here the true essence of intelligent behavior.

Experimental studies of intelligence. To experiment requires control of the essential conditions of the activity to be analyzed; and it is not at all sure that we can get control of the essential conditions of intelligent action. We cannot prevent a person from seeing relationships, and then determine whether he can still pass an intelligence test. But *some* conditions can be controlled, and the results obtained are instructive.

Students who had previously taken an intelligence test, and whose records were known, remained *without sleep* for 72 consecutive hours, at the end of which time they took a different but equivalent intelligence test; and their performance fell off 25% from their normal. This experiment shows that wide-awakeness is necessary for high intelligence. Intelligence demands, or consists partly in, *alertness*.[7]

In order to see the effects of *active hunger* upon performance in an intelligence test, a rubber bulb was swallowed and connected with recording apparatus, so as to show when the hunger contractions of the stomach (felt as hunger pangs) occurred. The subject took a series of intelligence tests all day, without eating till evening. When the hunger contractions

[7] H. R. Laslett, *Journal of Experimental Psychology*, 1928, vol. 11, p. 391.

occurred, the subject's performance improved, to slump again when the hunger contractions ceased; and after the evening meal, though he felt much better able to do effective work, his score failed to reach the level of his hunger periods. A second subject gave the same results. The same results appeared in muscular efficiency as in mental. Perhaps we cannot conclude that hunger, per se, is a condition of intelligent behavior; but we can speak again of alertness.[8]

Correlational studies of intelligence. This type of study resembles the experimental type in using exact methods, but does not attempt to manipulate the conditions under which the activity occurs. Rather, it keeps the conditions constant, but examines a considerable number of people with the object of seeing what other characteristics of individuals go along with intelligence. Suppose we notice an individual who is very quick as well as very intelligent, and another individual who is very slow as well as very dull. It would be jumping to a conclusion, decidedly, to assert from these two cases that intelligence went with quickness; but the hypothesis would be worth trying out. Assemble a considerable number of people, ranging from bright to dull, measure their intelligence as accurately as possible, and also give them adequate speed tests, and see how much correspondence, if any, there is between the two "variables," intelligence and speed. Do we find in the results an absolute rule that the more intelligent an individual is, the quicker he is? Do we find a general rule, but with exceptions? Do we find so many exceptions as almost to destroy the rule, do we find no rule at all, or do we even find, from the results as a whole, that the tendency is in the opposite direction? In a word, how close a correspondence is there between an individual's quickness and his intelligence? Or, to use another and more technical word, how close is the *correlation* between speed and intelligence? Correlation is

[8] Tomi Wada, *Archives of Psychology*, 1922, no. 57, pp. 47–48.

a mathematical measure of the degree of correspondence. Suppose, of fifty individuals measured, the quickest was the most intelligent, the second in quickness the second in intelligence, the third the third, and so on down through the list, with no exceptions. Then the correlation would be perfect, and expressed by the figure, +1. Suppose there were just a few minor exceptions; then the correlation might be +.90. If there were a good many exceptions, individuals of average quickness who ranked high or low in intelligence, and even very slow individuals who ranked high in intelligence, or the reverse, then the correlation might come out at +.50. Suppose there were no real correspondence on the whole, the correlation would be 0. And if, on the whole, the slower individuals were the more intelligent, the correlation would be negative, —.30, —.60, and so on down to —1, a perfect negative correlation.

Mathematicians have devised formulas to measure correlation, formulas which give the value +1, for perfect positive correlation, —1 for perfect negative correlation, 0 for no correspondence at all, and fractional positive or negative values for each degree of correlation. The formulas take due account of the number and seriousness of the exceptions to the rule. If the correlation comes out at +.90, you see that there is a definite rule, with few exceptions; but if it comes out at +.30, you see that, while there is a rule, it is practically snowed under with exceptions.[9]

[9] Possibly some readers would like to see a sample of the statistical formulæ by which correlation is measured. Here is one of the simplest. Number the individuals tested in their order as given by the first test, and again in their order as given by the second test, and find the difference between each individual's two rank numbers. If an individual who ranks no. 5 in one test ranks no. 12 in the other, the difference in his rank numbers is 7. Designate this difference by the letter D, and the whole number of individuals tested by n. Square each D, and get the sum of all the squares, calling this sum "sum of D^2." Then the correlation is given by the formula,

$$1 - \frac{6 \times \text{sum of } D^2}{n\,(n^2 - 1)}$$

In correlation studies, the two variables related stand on a par. You cannot say, without further evidence, that one is cause and the other effect. You can only say that, since they go together, they must have something in common, they must have causes in common, or factors in common. If we found a good correlation between quickness and intelligence, we could not, without further study of the matter, conclude that quickness was the cause of intelligence, or that

---

As an example in the use of this formula, take the following:

Individuals tested	Rank of each individual in first test	Rank of each individual in second test	D	D^2
Albert	3	5	2	4
George	7	6	1	1
Henry	5	3	2	4
James	2	1	1	1
Stephen	1	4	3	9
Thomas	4	2	2	4
William	6	7	1	1

$$n = 7 \qquad \text{sum of } D^2 = 24$$

$$n^2 - 1 = 48 \qquad 6 \times \text{sum of } D^2 = 144$$

$$1 - \frac{6 \times \text{sum of } D^2}{n(n^2 - 1)}$$

$$= 1 - \frac{144}{7 \times 48}$$

$$= +.57$$

In order to get a full and true measure of the correlation between two tests, the following precautions are necessary:

(1) The *same individuals* must be given both tests.

(2) The number of individuals tested must be as great as 15 or 20, preferably more.

(3) The individuals should be a fair sample of the population in regard to the abilities tested; they should not be so selected as to represent only a small part of the total range of ability.

(4) The tests should be thorough enough to determine each individual's rank in each test, with a high degree of certainty. Sloppy testing gives a correlation nearer zero than it should be, because it "pies" the true orders to some extent.

intelligence was the cause of quickness, but only that there was some strong factor common to quick action and intelligent action. If the correlation were very high, you would know that quick action and intelligent action were almost the same thing; if the correlation were low, you would know that, while there was something common to the two, there was more that was different.

Psychologists have long been on the trail of a possible connection between quickness and intelligence, and on the whole have found a low positive correlation. Recently, however, what looked like an unpromising lead, on being followed, has given astonishingly definite results. You might expect a fair correlation between intelligence and quickness in intellectual tasks, but you would hardly expect to find much but zero correlation between intelligence and the speed of the simplest reflex movements. One such reflex is the knee jerk, easily obtained by crossing the legs, and giving a smart tap on the patellar tendon, just below the knee of the suspended leg. It is a brisk, brief movement, wholly involuntary, dependent on the lower parts of the nervous system rather than on the brain, though subject to strengthening and weakening influences from the brain. The contraction of the thigh muscle which gives the forward kick of the foot in this experiment follows very quickly after the tap on the tendon. It is one of the quickest reflexes. Yet it differs in quickness from one individual to another; one individual's reflex movement gets started in half the time taken by another individual.

The Achilles tendon reflex is very similar to the knee jerk, but not so easy to get. The tap is applied to the tendon just above the heel, and the reflex downward thrust of the foot is the work of the calf muscles. Like the knee jerk, this reflex is very quick, but the time required to set the movement off differs from one individual to another in the ratio of two or three to one.

Now what possible connection can there be between such reflexes and intelligence?

In one recent investigation,[10] the reflex time of the knee jerk was measured for each of a group of persons whose standing in an intelligence test was also determined. The subjects ranged from high to low in intelligence, and also in reflex speed, and the correlation between the two came out at the high figure of +.87. The experiment was repeated with another group, with the same result. Simultaneously and without knowing of the work just mentioned, another investigator [11] was correlating the time of the Achilles tendon reflex with the scores in a team of mental tests, and he obtained a figure of +.60. Though this figure is considerably below the remarkably high figure obtained in the other investigation, both are high enough to indicate a genuine and important connection between intelligence and simple reflex speed.

Now for an interpretation of these findings. Reflex speed is probably a pretty direct indicator of the speed of the elementary activities in the nervous system. If the elementary processes in the brain are quick, the total brain activity is probably more efficient. If each little part of the brain does its job promptly, the whole brain works together as a team, while if the parts lag, the team work of the whole is imperfect. Now if intelligent behavior requires dealing with the pattern of a complex situation, brain team work is essential. Liken the brain to a team of players — an inconceivably big, complex team. Suppose this team confronted by a novel situation. If each player gets instantly into action, the team as a whole responds to the pattern of the situation; but if the players lag, some doubtless lagging more than others, there is no co-ordinated response to the situation as a whole.

[10] L. E. Travis and T. A. Hunter, *Journal of Experimental Psychology*, 1928, vol. 11, pp. 342–354.

[11] G. H. Rounds, *Archives of Psychology*, 1928, no. 85, p. 58.

The interpretation is speculative; but undoubtedly quickness of elementary activities is to be accepted as part of our analysis of intelligence, just as alertness was accepted on the basis of experimental evidence. But whether the analysis is complete or not is another question — probably not.

The correlation of abilities. Besides the general intelligence tests, there are tests for many special abilities, ranging from speed and accuracy of hand movements to the solving of logical puzzles. When a correlation is worked out between two tests, the result is usually a low positive figure, unless the tests are very similar. Very seldom if ever is a genuine negative correlation found between different abilities. Almost any two abilities, then, have something in common. This might mean that there was one general factor entering into every sort of performance. The general factor might be the elementary nerve quickness just spoken of, or it might be called alertness, or breadth, or some compound of these. But the truth might be something quite different. Any two performances might have something in common, as indicated by the positive correlations, but what was common to adding and memory for numbers might be a special facility with numbers, while what was common to memory for numbers and memory for poetry might be skill in committing to memory, and again what was common to memory for poetry and the ability to understand poetry might be previous training in the reading of poetry. There doubtless are a lot of these special factors tying one performance to another, but whether there is any general factor running through all performances is a matter of much dispute. We may mention two leading psychologists who take stands on this question.

Spearman, from an elaborate and subtle study of correlations, decides that there is a single general factor running through all intelligent behavior. Exactly how this general factor should be described, the evidence does not show; he

calls it simply "general ability," and more commonly designates it as "G." Success in any performance depends more or less upon G, but success in any performance also depends on special factors peculiar to that and similar performances. In arithmetical work, facility with numbers enters as a special factor, along with G; in a musical performance, the special musical ability enters along with G.

Thorndike, another eminent student of intelligence, doubts the existence of G. The factors common to two performances are always, he believes, very specific. What we mean by "general intelligence," and measure in a general intelligence test, is simply a summation of numerous special abilities.

EXERCISES

1. Outline the chapter. The student will find the preparation of an outline, especially such a one as he could later use himself, a more useful expenditure of time than the immediate re-reading of a chapter. It is suggested that the following outline be completed:

A. Preliminary definition of intelligence:

Intelligent behavior demands (a) learning, (b) taking account of the novelty of a situation, and (c) taking account of the breadth of a situation.

B. Measurement of intelligence

(1) Tests present definite problems on which the testee can be scored.

(a) The Binet tests use problems graded in difficulty to fit children of every age; tests given orally.

(b) Performance tests make less use of language and more of concrete material to be managed by the testee.

(c) Group tests may use printed language and call for written replies, or may be of performance type.

(2) Scoring devices

(a) Mental Age of an individual is the age norm or average which he equals.

(b) Intelligent Quotient is his Mental Age divided by his Chronological Age.

C. Individual differences in intelligence

(a) Rough division into normals and subnormals, and subdivision of subnormals into idiots (the lowest), imbeciles and morons.

(b) Test results show a continuous gradation from the lowest idiot to the highest intelligence.

D. Constancy and meaning of the IQ

(a) The average IQ is 100 for all ages (except for flaws in the tests).

(b) The IQ of an individual usually differs somewhat from test to test, but seldom changes much.

(c) The IQ measures the rate of mental development (from birth to date of test).

(d) Assuming constancy for an individual's IQ, we can predict from test results his probable Mental Age at any future time.

E. How long intelligence continues to develop

. . . .

F. . . . .

and so on

2. Compute the IQ of the following individuals:

A.	Chronological Age	4 yrs, 6 mos;	Mental Age	5 yrs, 2 mos
B.	" "	7 yrs, 9 mos;	" "	5 yrs, 2 mos
C.	" "	8 yrs, 4 mos;	" "	11 yrs, 0 mos

3. Show two ways in which mental ability can increase beyond the age when intelligence has reached its full development.

4. Show that the use of intelligence tests for prediction does not rest on the assumption that the IQ is wholly determined by heredity.

5. Just how is the childhood IQ of a person estimated from his biography? Do you find any data in the case history in the first chapter that could be used for such an estimate?

6. What do you understand by the term, " migrational selection " ? Show that this factor may operate to raise or to lower the average of an immigrant group.

7. How might public provision for the feeble-minded diminish the number of feeble-minded criminals?

8. Show how difficult it is to find out whether two races differ in real mental capacity.

9. Give at least two reasons why it is more difficult to predict academic success in college from the results of an intelligence test, than it is in the elementary school.

10. Name some factors which might cause slight or even marked changes in the IQ of a child when he was retested after a lapse of time.

11. What becomes of the exceptional cases in computing correlations?

12. Is there anything in this chapter to lead you to expect athletes as a group to be lower in intelligence than the average of the group from which they were selected? Or higher?

13. Write an essay on "Causes of Stupid Behavior."

REFERENCES

Among many recent books on intelligence testing, reference may be made to F. N. Freeman, *Mental Tests, Their History, Principles and Applications,* 1926; and to the chapters on "The Measurement of Intellectual Traits" and on "The Uses and Results of Intelligence Testing," in R. Pintner, *Educational Psychology,* 1929. See also C. L. Hull, *Aptitude Testing,* 1928.

For a brief account of different conceptions of intelligence, see P. Sandiford, *Educational Psychology,* 1928, pp. 142–166.

More advanced works by two of the leaders in this study are C. Spearman, *The Abilities of Man,* 1927; and E. L. Thorndike, *The Measurement of Intelligence,* 1926.

For an anthropologist's point of view on the question of race differences, see F. Boas, *Anthropology and Modern Life,* 1928.

For methods of measuring correlation, see H. E. Garrett, *Statistics in Psychology and Education,* 1926.

CHAPTER III

MEMORY

HOW WE MEMORIZE AND REMEMBER, AND IN WHAT WAYS MEMORY CAN BE MANAGED AND IMPROVED

So much depends on a good memory in all walks of life, and especially in brain work, that it is no wonder students and business and professional men become worried about their memories and resort to memory training courses in the hope of improvement. But just here scientific study is of great practical value, and the best way to go about improving one's memory is to know the facts and laws of memory.

The reason for putting the topic of memory so early in our study is that it gives us an insight into the process of learning, and learning is one of the most fundamental facts of psychology. In examining the life history of an individual, we are impressed by the development that occurs, in knowledge, skill and power, and we are sure that this development depends partly on experience and training. The individual learns one thing after another, and develops by the accumulation of what he has learned. We are not sure that mental development consists *entirely* in learning, for there is the possibility that mental power increases by a process of natural growth, just as muscular power does. One of the most certain facts brought out in the study of intelligence was its development through childhood and early youth. Now is this development of intelligence simply a natural growth in brain power, or is it simply the accumulation of knowledge and skill that have been learned — or is it partly one and partly the other? In

behavior generally, there is a great difference between the baby kicking in his cradle and the same person twenty years later, working at his job. The adult has desires and fears that the child is entirely innocent of; is all this change the result of growing up, or the result of experience and learning, or how much of one and how much of the other? The best way for the psychologist to present his evidence on this question is first to show what can be accomplished by learning, and then to consider whether all mental development is thus accounted for, or whether any of it is left over to be explained by the growth process.

There are so many varieties of learning to be surveyed that one hardly knows where to begin. It would be logical enough to start with the simplest forms of learning in animals, and work our way gradually up to the most intellectual type of human learning. But there is something to be said, on the other hand, for starting with human memory, more or less a familiar process to everybody, and working our way gradually downward.

In defining memory, we should first repeat what has been said before, that this noun is properly a verb. The real fact is "remembering." How does remembering differ from thinking? Both make use of past experience. Suppose that a problem — let us say a conundrum — is put to two persons, one of whom has heard it before and remembers the answer, while the other has to think it out. The latter uses past experience, putting two and two together to build up a solution, but the former has a ready-made answer, derived directly from past experience. Memory, then, is a direct use of what has been learned, while thinking is an indirect use of what has been learned. Remembering is performing a ready-made act, while thinking is doing something partially new and different.

There are two ways of remembering, or at least two ways of proving that you remember. These two are called *recall* and

recognition. Suppose the titles of ten new books are read to you, and later you are asked to write down all of them you remember, and you succeed in writing down five. You prove your memory of these five by recalling them. Now suppose that the ten titles are mixed with ten other book titles that you have not heard, and you are asked to tell which of these twenty you remember. It may be that you succeed in identifying all the titles previously heard, with no errors. The recognition test proves that you have some sort of memory of all the titles, in spite of your failure to recall half of them. The supposed result is rather typical, since more can usually be recognized than can be recalled. Faces can certainly be recognized more easily than they can be recalled; and people's names as well, since often a name cannot be recalled and yet is confidently recognized as soon as spoken by some one. Yet, on the other hand, you may recall a name correctly, and yet think you have not got it right; here you recall without recognizing. More than once it has happened that a writer or musical composer has unintentionally plagiarized the work of another, so reproducing what he has read or heard but without recognizing it. Recall and recognition are thus different enough to warrant separate consideration, even if fundamentally they may prove to be the same process.

Remembering proves previous learning; and it proves something more, since what was learned must have been *retained* during the interval between learning and remembering. We have then four main subtopics under the general head of memory: Learning, Retention, Recall, Recognition.

MEMORIZING, OR INTENTIONAL LEARNING

Memory is one of the parts of psychology where experiments have been most fruitful. In a typical memory experiment, the "subject" (or individual under observation) first memorizes certain material; then an interval, longer or shorter, elapses

without his doing anything at all with this material; and finally his memory of this material is tested. So far as possible, all the conditions — such as kind of material, length of lesson, rate of presentation, state and attitude of the subject — are controlled with the object of discovering what conditions are favorable and what conditions unfavorable for a memory performance.

The material must of course be partially unfamiliar, so as to leave something to be learned. Wholly unfamiliar material can scarcely be found, but nonsense syllables, nonsense drawings, disconnected words or numbers, etc., are much used in memory experiments.

The immediate memory span. A short series of disconnected words or numbers can be reproduced entire a few seconds after seeing or hearing it. One of the simplest memory experiments consists in presenting lists of numbers, and discovering how long a list the subject can reproduce perfectly after one presentation. Such lists as the following are used:

518
3296
70461
927358
4016372
24971306
176028395
6381470259
85079153624
082649138574

Several lists of each length have to be tried, in order to allow for slips and flukes. An individual may have no trouble at all with lists of three, four or five, and may succeed every time with lists of six, and usually with lists of seven, but only seldom with the longer lists. His " immediate memory span for

digits" would then be approximately seven, about the average for a young adult. Children of four to six have a span of about four digits, and the average increases gradually up to the age of eighteen.

Memorizing of longer lessons. If the list of numbers to be memorized exceeds the memory span, several readings are necessary before it can be recited. Of course! — but it is really rather strange. Suppose your memory span is eight digits; why should you not be able to hold eight digits while reading another eight, and then recite the whole sixteen, after a single reading? Is it the mere lapse of time that causes the first eight to disappear while the second eight are being read? Try this experiment: read six digits (keeping well within your memory span), and follow on immediately by saying "one — two — three — four — five — six," so as to occupy the same time as reading six fresh digits while at the same time preventing yourself from rehearsing the first six; and then see whether you cannot recite these first six digits without trouble. If you can, something besides the mere lapse of time prevents you from adding span to span, and learning twelve, eighteen, or more in a single reading. One set of six disturbs the other; there is some interference, some *inhibition* (to use the technical term for the checking of an activity). Grasping the second handful, or span of digits, loosens your hold on the first handful. We have here an important elementary fact of memorizing.

Another elementary fact comes to light if you go over the long list of numbers two, three, four or more times. It may seem that you are never going to get them; but after a number of repetitions you realize that the list is almost in hand, and after a few more repetitions, there it is! You can recite the whole list without error and even without effort. You can learn a list of a hundred numbers if you keep at it long enough.

The learning curve. The mastery of a long list is a gradual process, and the rate of progress can be measured if the subject, after each reading, recites as much as he can. If count is kept of the number of items correctly recited after each reading, a curve can be plotted to show the rate of progress in fixing the list. The curve starts upwards rather steeply, but flattens out as it approaches the 100 per cent. level. The learning curve will be considered more fully in the next chapter.

The process of memorizing. So far, we have three fundamental facts regarding memorizing: the memory span or grasp, inhibition of grasp when too much material is grasped at, and the overcoming of this inhibition by repetition. The grasp and the inhibition are basic processes regarding which there is little to be said except that they are there, and that they are basic. But the overcoming of inhibition is a gradual process which can be watched. It is an active and varied process.

Suppose a list of twenty digits is to be memorized. As the learner wades into the long list, and finds himself getting out of his depth, he grasps at anything to help. He no longer simply takes the numbers as they come, but looks for *groups* that will hang together. Any familiar group, such as the sequence 1492, he hails with joy. If he finds nothing so soft as that, he at least notes similarities and contrasts, or any *relationships* that tie the different parts of the list together — anything to raise the list above the dead level of a mere series of single numbers. If the reader cares to memorize the following list of twenty, he will probably find something interesting in his way of attacking the problem.

2 6 0 1 3 6 4 2 8 1 9 4 7 6 8 9 0 1 2 7

In general, the process of memorizing, as revealed in this case, is far from passive rote learning. Rather, it is active and observant, and makes all possible use of combinations and meanings.

Lists of nonsense syllables, such as

wok pam zut bip seg ron taz vis lub mer koj yad

are usually learned by grouping, by observing similarities and contrasts, and by reading meaning into the single syllables or their combinations. Often the subject accents the first syllable of each pair, and finds that the rhythm thus introduced aids in memorizing. Many are the devices hit upon, and some of them work better than others, but they all reveal the learner as actively searching for combinations that shall be familiar, meaningful, or somehow characteristic, and thus useful in tying the items together.

Different types of memorizing. The learner's line of attack differs according to the particular test that is later to be made of his memory. Suppose he is shown a number of pictures to be identified later — then he simply examines each picture for something characteristic. But suppose each picture is given a name, and he must later tell the name of each — then he seeks for something in the picture that can be made to suggest its name. Or suppose, once more, that the pictures are spread out before him in a row, and he is told that he will later have to arrange them in the same order — then he seeks for relationships between the successive pictures. His process of memorizing, always active and observant, differs in detail with the kind of memory task in hand.

For another example, suppose an experiment is conducted by the method of "paired associates." The subject is handed a list of paired words, such as

soprano ..... emblem
grassy ...... concise
nothing ...... ginger
faraway ..... kettle
shadow ...... next
mercy .... scrub
hilltop .... internal

recite	shoestring
narrative	thunder
seldom	harbor
jury	eagle
windy	occupy
squirm	hobby
balloon	multiply
necktie	unlikely
supple	westbound
obey	inch
broken	relish
spellbound ...	ferment
desert	expect

He must learn to answer with the second word of each pair when the first word of the pair is given. The way he learns this lesson is to take each pair as a unit and look for something in it to bind it together — the more swing or rhythm of the pair of words, or some connection of meaning. Perhaps the pair suggests a scene or action, however bizarre. A pair that gives a laugh is an easy pair. A few readings fix most of the pairs.

But suppose the experimenter now springs a surprise, by asking the subject to recite the pairs in order. The subject fails almost completely, and protests that the test is not fair, since he paid no attention to the order of the pairs, but only to each pair by itself. Had he expected to recite the whole list of pairs in order, he would have noted relationships between one pair and another, and perhaps woven them into a sort of continued story. He would have memorized according to what he wanted to remember.

In memorizing *connected passages* of prose or verse, the efficient procedure consists in noting the general sense of the passage, the place of each part in the general scheme, the structure of the sentences and the author's choice of particular words. Memorizing is here greatly assisted by the familiar sequences of words and by the connected meaning of the whole, with the

result that a connected passage is learned in a fraction of the time needed to memorize the same number of disconnected words. No one in his senses would undertake to memorize an intelligible passage by mere rote learning, for he would be throwing away the best possible aid in memorizing. The greater the student's need for remembering a passage, the more he should be alert to the connected sense of the whole. For fixing in mind the sense of a passage, the essential thing is to get the sense. Once you see the point, you have learned it.

Short-circuiting. The peculiarities of words or syllables in a list or passage that is being memorized, the relationships observed among the parts, and the meanings suggested or imported into the material, though very useful in the early stages of memorizing, tend to drop out of mind as the material becomes familiar. A pair of syllables, "lub — mer," may have first been associated by turning them into "love mother," but later this meaning fades out, and the two syllables seem simply to belong together in their own right. A pair of words, like "seldom — harbor," that were first linked together by the intermediary thought of a boat that seldom came into the harbor, become directly bound together as mere words. A short-circuiting occurs, indirect attachments giving way to direct. Even the outline and general purpose of a connected passage may fade out of mind, when the passage becomes well learned, so that it may be almost impossible for a schoolboy, who has learned his little speech by heart, to deliver it with any consciousness of its real meaning. A familiar act flattens out and tends to become automatic and mechanical.

ECONOMY IN MEMORIZING

Memorizing is a form of mental work that is susceptible of management, and several principles of scientific management have been worked out that may greatly assist in the learning of a long and difficult lesson. The problem has been ap-

proached from the angle of economy or efficiency. Suppose a certain amount of time is allowed for the study of a lesson, how can this time be best utilized?

The first principle of economy has already been sufficiently emphasized: observant study, directed towards the finding of relationships and significant facts, is much more efficient than mere dull repetition.

The value of recitation in memorizing. "Recitation" here means reciting to oneself. After the learner has read his lesson once or twice, he may, instead of continuing simply to read it, attempt to recite it, prompting himself without much delay when he is stuck, and verifying his recitation by reference to the paper. The question is whether this active reciting method of study is or is not economical of time in memorizing, and whether or not it fixes the lesson durably in memory. The matter has been thoroughly tested and the answer is unequivocally in favor of recitation. The only outstanding question is as to how soon to start attempting to recite, and probably no single answer can be given to this question, so much depends on the kind of material studied, and on peculiarities of the individual learner. Where the sense rather than the exact wording of a lesson has to be learned, it is probably best to recite, in outline, after the first reading, and to utilize the next reading for filling in the outline.

The results of one series of experiments on this matter are summarized in the table on the next page.

Two facts stand out from the table: (1) Reading down the columns, we see that recitation was always an advantage. (2) The advantage was more marked in the test conducted four hours after study than in the test immediately following the study. To be sure, there is always a falling off from the immediate to the later test; there is bound to be some forgetting when the lesson has been studied for so short a time as here; but the forgetting proceeds more slowly after recita-

THE VALUE OF RECITATION IN MEMORIZING (from Gates)

Material studied	16 nonsense syllables		5 short biographies, totalling about 170 words	
	Percent immediately	*remembered after 4 hours*	*Percent immediately*	*remembered after 4 hours*
All time devoted to reading	35	15	35	16
1/5 of time devoted to recitation	50	26	37	19
2/5 of time devoted to recitation	54	28	41	25
3/5 of time devoted to recitation	57	37	42	26
4/5 of time devoted to recitation	74	48	42	26

The time devoted to study was in all cases 9 minutes, and this time was divided between reading and recitation in different proportions as stated in the first column at the left. Reading down the next column, we find that when nonsense syllables were studied and the test was conducted immediately after the close of the study period, 35 percent were remembered when all the study time had been devoted to reading, 50 percent when the last 1/5 of the study time had been devoted to recitation, 54 percent when the last 2/5 of the time had been devoted to recitation; and so on. The next column shows the percents remembered four hours after the study period. Each subject in these experiments had before him a sheet of paper containing the lesson to be studied, and simply read till he got the signal to recite, when he started reciting to himself, consulting the paper as often as necessary, and proceeded thus till the end of the study period. The subjects in these particular experiments were eighth grade children; adult subjects gave the same general results.

tion than after all reading. Recitation fixes the matter more durably.

Whence comes the advantage of recitation? Can we learn anything here of general psychological interest? Well, for one thing, recitation is more stimulating than continued re-reading

of the same lesson can be. When you know that you are going to try at once to recite what you are now reading, you have an immediate goal, and are stimulated to make the best use of your time. Then, each recitation shows you where you have succeeded and where your further efforts are most needed. Recitation thus releases energy and directs it economically.

But perhaps the main advantage of recitation is something a little less obvious than this matter of stimulation and check-up. In reciting you perform, as far as possible, the very act you are trying to learn; for you are trying to learn to recite the lesson without the book. *Memorizing consists in performing an act, with assistance, that you wish to perform later without assistance;* and recitation, by eliminating the assistance as fast as you can do without it, forces you into performing the very act you are trying to learn.

Spaced and unspaced repetition. Another question on the economical management of memorizing: Is it better to keep steadily going through the lesson till you have it, or to go through it at intervals? If you were allowed a certain time, and no more, in which to prepare for examination on a certain memory lesson, how could the study time be best distributed? This question also has received a very definite answer.

Spaced repetitions are more effective than unspaced. In an experiment of Piéron, a practiced subject went through a list of twenty numbers with an interval of only thirty seconds between readings, and needed eleven readings to master the list. But a similar list, with five-minute intervals, was mastered in six readings; and the number of readings went down to five with an interval of ten minutes, and remained the same for longer intervals up to two days. With this particular sort of lesson, then, ten minutes was a long enough interval, and two days not too long, to give the greatest economy of time spent in actual study.

In a somewhat different experiment in another laboratory,

lists of nonsense syllables were studied either two, four, or eight times in immediate succession, and this was repeated each day till a total of twenty-four readings had been given to each list; then, one day after the last reading of each list, the subjects were tested as to their memory of it. The result appears in the adjoining table.

EFFECT OF SPACED STUDY ON ECONOMY OF MEMORIZING
(From Jost, 1897)

Distribution of the 24 readings	*Total score of Mr. B.*	*Total score of Mr. M.*
8 readings a day for 3 days	18	7
6 " " " " 4 "	39	31
2 " " " " 12 "	53	55

The widest distribution of the readings here gave the best score; and other experiments have generally given similar results. Undoubtedly, then, if you had to memorize a long poem or speech, you would get better value for time spent if you gave it one or two readings at a time, with intervals of a day, than if you attempted to finish the job at one sitting.

Spaced study also fixes the matter more durably. Every student knows that continuous cramming just before an examination, while it may accomplish its immediate purpose, accomplishes little for permanent knowledge.

When we say that spaced repetitions give best results in memorizing, that does not mean that study generally should be in short periods with intervals of rest; it says nothing one way or the other on that question. The probability is, since most students take a certain time to get well "warmed up" to study, that fairly long periods of consecutive study would yield larger returns than the same amount of time divided into many short periods. What we have been saying here is simply that repetition of the *same material* fixes it better in memory,

when an interval (not necessarily an empty interval) elapses between the repetitions.

Whole versus part learning. In memorizing a long lesson, is it more economical to divide it into parts, and study each part by itself till mastered, or to keep the lesson entire and always go through the whole thing? Most of us would probably guess that study part by part would be better, but experimental results have usually been in favor of study of the whole.

If you had to memorize 240 lines of a poem, you would certainly be inclined to learn a part at a time; but notice the following experiment. A young man took two passages of this length, both from the same poem, and studied one by the whole method, the other by the part method, in sittings of about thirty-five minutes each day. His results appear in the table.

LEARNING PASSAGES OF 240 LINES, BY WHOLE AND PART METHODS (Pyle and Snyder, 1911)

Method of study	*Number of days required*	*Total number of minutes required*
30 lines memorized per day, then whole reviewed till it could be recited	12	431
3 readings of whole per day till it could be recited . . .	10	348

In this experiment, the whole method gave an economy of eighty-three minutes, or about twenty per cent., over the part method. Other similar experiments have given smaller differences, and sometimes the advantage has been with the part method.

The experiment most strongly against whole learning was made with a very different sort of performance to be learned. A "pencil maze," consisting of passages or grooves to be

traced out with a pencil, while the whole thing was concealed from the subject by a screen, was so arranged that it could be divided into four parts and each part learned separately. Four squads of learners were used. Squads A and B learned the maze as a whole, squads C and D part by part. Squads A and C learned by spaced trials, two trials per day. Squad B learned the whole thing at one sitting; while squad D, which came off best of all, learned one part a day for four days, and on the fifth day learned to put the parts together. The results appear in the adjoining table, which shows the average time required to master the maze by each of the four methods.

PART AND WHOLE LEARNING, SPACED AND UNSPACED, IN THE PENCIL MAZE (From Pechstein, 1917)

	Spaced trials	*Unspaced trials*
Whole learning	A 641 seconds	B 1250 seconds
Part learning	C 1220 "	D 538 "

When the trials were spaced, the whole method was much the better; but when the trials were bunched, the part method was much the better; and, on the whole, the unspaced part learning was the best of all. Thus the result stands in apparent contradiction with two accepted laws: that of the advantage of spaced learning, and that of the advantage of whole learning.

This contradiction warns us not to accept the "laws" too blindly, but rather to analyze out the factors of advantage in each method, and govern ourselves accordingly. Among the factors involved are the following four:

(1) The factor of interest, confidence and visible accomplishment — the emotional factor, we might call it. This is on the side of part learning, especially with beginners, who soon feel out of their depth when wading into a long lesson, and lose hope of ever learning it in this way. This factor is also largely

on the side of unspaced as against spaced learning, when the part studied is of moderate length and when there are recitations to keep up the interest; for when the learner sees he is getting ahead, he would rather keep right on than wait for another day to finish. To have a task that you can hope to accomplish at once, and to attack it with the intention of mastering it at once, is very stimulating.

(2) The factor of recency, of "striking while the iron is hot." When an act has just been successfully performed it can easily be repeated, and when a fact has just been observed it can readily be put to use. This factor is clearly on the side of unspaced learning; and it is also on the side of part learning, since by the time you have gone through the whole long lesson and got back to where you are now, the recency value of what you have just now accomplished will have evaporated.

(3) The factor of meaning, outlining and broad relationships. This is on the side of whole learning, for it is when you are going through the whole that you catch its general drift, and see the connections of the several parts and their places in the whole. This factor is so important as to outweigh the preceding two in many cases, especially with experienced learners dealing with meaningful material. Even if you incline to the part method, one careful reading of the whole is probably the best way to begin. So you can locate the parts that call for minute examination.

(4) The factor of permanency. This is something "physiological," and it is on the side of spaced learning. The muscles certainly profit more from exercise with intervals of rest than by a large amount of continuous exercise, and no athlete would think for a moment of training for a contest of strength or speed by "cramming" for it. The brain, apparently, obeys the same law as the muscles, and for that reason spaced learning gives more durable results than unspaced.

UNINTENTIONAL LEARNING

What we have been examining is intentional memorizing, with the "will to learn" strongly in the game. The assertion has sometimes been made that the will to learn is necessary if any learning is to be accomplished. We must look into this matter, for it has an important bearing on the whole question of the process of learning.

There is a famous incident that occurred in a Swiss psychological laboratory, when a foreign student was supposed to be memorizing a list of nonsense syllables. After the list had been passed before him many times without his giving the expected signal that he was ready to recite, the experimenter remarked that he seemed to be having trouble in memorizing the syllables. "Oh! I didn't understand that I was to learn them," he said, and it was found that, in fact, he had made almost no progress towards learning the list. He had been observing the separate syllables, with no effort to connect them into a series.

Another incident: subjects were put repeatedly through a "color naming test," which consisted of five colors repeated in irregular order, the object being to name the one hundred bits of color as rapidly as possible. After the subjects had been through this test over two hundred times, you would think they could recite it from memory; but not at all! They had very little memory of the order of the bits of color. Their efforts had been wholly concentrated upon naming the bits as seen, and not in connecting them into a series that could be remembered.

The experiment described a few pages back on "paired associates" is another case in point. The subjects memorized the pairs, but made no effort to connect the pairs in order, and consequently were not able later to remember the order of the pairs.

Similar experiments have sought to measure the *reliability*

of testimony, and have shown that the testimony of eyewitnesses is very unreliable except for facts that were definitely noted at the time. Enact a little scene before a class of unsuspecting students, and later quiz them on the facts that transpired before their eyes, and you get an astonishing amount of hazy and even false testimony.

These facts all emphasize the importance of the will to learn. But let us consider another line of facts. An event occurs before our eyes, and we do notice certain facts about it, not with any intention of remembering them later, but simply because they arouse our interest; but later we recall such facts with great sureness. Or, we hear a tune time after time, and come to be able to sing it ourselves, without ever having attempted to memorize it. Certainly the little child learns much in his play and in watching people and things, though with no definite intention of learning.

What is the difference between the case where the will to learn is necessary, and the case where it is unnecessary? The difference is that in the one case the fact would not be observed, the act would not be performed, except for the desire to learn them for future use, whereas in the other case the fact is observed or the act performed for some other reason. In both cases the learning consists in observing the fact or performing the act. Learning seems not to be any special kind of activity. Learning a fact consists in observing that fact, and learning an act consists in performing that act. In general, learning consists in going through with the activity to be learned.

THE FIXATION OR CONSOLIDATION OF WHAT HAS BEEN LEARNED

When the active memorizing process ends, is the fixation of what has been learned ended too, or is there a quiet process of consolidation still going on for a few hours at least — some sort of growth process in the brain, strengthening the mechanism that has been active in memorizing? There is such an

after-process in the muscles, and by analogy we might expect it to occur in the brain. When a person who has been confined to his bed for weeks is first permitted to walk about the room, his muscles are weak and quickly fatigued. He can only walk a few steps. But the after-effect of this exercise is that the muscles are stronger the next day. They grow strong in the rest after exercise. By analogy, then, we may suppose that the brain mechanism thrown into activity in a new performance grows strong after the performance has come to rest. This idea was broached before as an explanation of the value of spaced learning. But are there any facts to support this theory of consolidation?

Shock amnesia. If there is such a process, it might be interfered with by a shock, such as a blow on the head. Cases like the following have been frequently reported. A young man, while out in the hills with some friends, fell from a tree upon his head, cutting the scalp and being knocked unconscious for a few moments. He soon recovered enough to walk the three miles to his home, conducting himself in a fairly normal manner, though in a sort of daze, from which he gradually emerged after some hours, with no memory of the walk home, nor of the fall from the tree, nor of a period of some fifteen minutes *before* the fall. The shock effect, then, was retroactive; it caused an amnesia (loss of memory) for events that happened just before the shock, just as if it checked a process of consolidation. The amnesia for what happens during high fever, or during intoxication, may similarly be due to abnormal brain conditions preventing consolidation.

Retroactive inhibition. Consolidation might be favored by a restful, easy occupation immediately after memorizing, and might be disturbed and partially inhibited by strenuous mental activity just then. Experiment has shown that such is the fact. For example, the position of five chess men on the board was studied for fifteen seconds, and then the subject immedi-

ately shifted to adding columns of numbers, keeping this up for a minute, after which he attempted to reconstruct the arrangement of the chess men. The interpolated activity increased the number of errors by 50 per cent. over what it was when the subject simply rested during the interval.[1] There are many similar experiments with various memory tasks, and on the whole, they give evidence of retroactive inhibition, though sometimes the effect is very slight. The greatest inhibitory effect is obtained by shifting from one memory task to another calling for the memorizing of the same sort of material.

Perseveration. There is often some sign of continued activity on the part of a mechanism that has recently been very active but now is supposed to be resting. If you have been busy with certain material, it may " bob into your head " at odd moments a little later. A tune may persist in " running in your head " when you wish it would stop. Scenes from the day's experience may flash before your " mind's eye " as you lie in bed before going to sleep. Important news, submerged during strenuous mental work, emerges as soon as there is a moment of relaxation. A recent activity that thus reasserts itself, without any apparent cue or stimulus to arouse it, is said to " perseverate." Some persons are much more subject to this perseveration than others.

The tendency of interrupted activities to perseverate. If you are prevented from completing an activity in which you have got well started and absorbed, this activity is specially likely to show perseveration. Such, at least, is the indication of a memory experiment [2] which dealt with the question in a novel way. The experimenter gave the subject a series of little tasks, each of which required a few minutes to complete. Specimen tasks were: to write down from memory a favorite poem, to model a dog in clay, to draw a vase with flowers according

[1] E. B. Skaggs, *Psychological Monographs,* 1925, no. 161.
[2] B. Zeigarnik. *Psychologische Forschung,* 1927, vol. 9, pp. 1–85.

to the subject's taste, to make a string of beads from a variety that were supplied, to multiply two four-place numbers, to solve a riddle. About twenty tasks were given to the subject one after another. But half of the tasks were interrupted by the experimenter, just when the subject seemed to be most absorbed in what he was doing; the experimenter simply said, "That is enough for that, now turn to this other task," at the same time removing the materials of the interrupted task from sight. As soon as the list of tasks was gone through, the experimenter asked the subject to mention all the tasks he had been busy with. Then this curious result appeared: in spite of the greater time put on the completed tasks than on the interrupted, the interrupted were better remembered. About 68% of the interrupted tasks were recalled, and about 43% of the completed. This disproportion disappeared for the most part if the memory test were delayed to the following day. Several alternative explanations being ruled out by variations of the experiment, the true interpretation of the facts seemed to be that an activity for which the subject was "all wound up" did not die down as quickly as one with which he was finished.

All in all, though the evidence for a consolidating process following active learning is rather scrappy and inconclusive, we have to reckon with the probability that a vivid experience, an intense activity, especially if cut short, is likely to persist in some form for a few minutes or hours.

RETENTION

We come now to the second of our four main problems, and ask how we retain, or carry around inside of us, what we have learned. Retaining, we can answer at once, is certainly not an activity. Rather, it is a resting condition in which anything that has been learned remains till it is called into activity again, i.e., till it is remembered. Consider, for example, the retention

of motor skill. A boy who has learned to turn a handspring does not have to keep doing it all the time in order to retain it. The skill remains in his possession, in an inactive state, even while he is asleep. The same can be said of the retention of the multiplication table, or of knowledge of any kind.

We carry around with us not the scenes we have seen, not the music we have heard, not the movements we have learned to make — in a word, not the activities we have learned — but the machinery for performing these activities. This machinery consists of structure, largely brain structure. Learning has modified brain structure in some minute details, so that the brain will behave in a different way after learning than it did before. It will behave in this different way so long as the modification remains. But the machinery developed in the process of learning is subject to the wasting effects of time. It is subject to the biological law of *atrophy through disuse*. Just as a muscle, brought by exercise into the pink of condition, and then left long inactive, loses the special structural condition produced by exercise, so it is with the brain changes produced by learning. The special brain condition produced in learning an act fades away with long-continued inactivity, and so the act is forgotten.

But is anything once learned ever completely forgotten and lost? Some say no, being strongly impressed by the occasional recovery of memories that were thought to be gone forever. Experiences of early childhood have sometimes been recovered after a long and devious search. Persons in a fever have been known to speak the language of their childhood which in their normal state they could not remember at all. Such facts have been generalized into the extravagant statement that nothing once known is ever forgotten. For it is an extravagant statement. It would mean that all the lessons you ever learned, all the stories you ever read, all the faces, scenes and happenings that ever attracted your attention could still be

recalled if only the right means were taken to revive them. There is no evidence for any such extreme view.

The scientific study of the matter began with the fact of degrees of retention, ranging from one hundred per cent. to zero, and with the invention of methods of measuring the degree of retention. You can prove your memory, as was said before, by recall or by recognition; and there is also a third way. If some time ago you memorized certain stanzas of a poem, it may be that you cannot now recall any of the lines; it may be you cannot even identify the stanzas you once learned; but you may find that you can now learn certain stanzas more easily than the rest, because you are *relearning* what you learned before. If it took you ten minutes to memorize a stanza originally, and now takes you only eight to relearn it, then retention is responsible for a saving of two minutes in relearning. The labor of relearning has been reduced by 20 per cent. through retention of the effects of the former learning, so that the retention, as measured by this saving method, amounts to 20 per cent.

It was by the use of this measure that the curve of retention, or curve of forgetting, as it is often called, was first discovered. The general shape of the curve has been confirmed by use also of the recall and recognition methods. The curve shows a gradual loss of retention with the lapse of time. But the rate of forgetting is not constant; rather, it is rapid at first, immediately after the end of the learning, and becomes slower and slower.

Though the general shape of the curve is well established by numerous experiments, the absolute speed of forgetting varies enormously in different cases. One individual forgets more rapidly than another. Material that has been "over-learned," i.e., studied beyond the point where it can barely be recited without error, is forgotten more slowly. Most important of all, meaningful material, besides being much more quickly

learned than nonsense material, is much more slowly forgotten. Nonsense material, barely learned, is almost entirely lost by the end of four months, but poetry, barely learned, has shown a perceptible retention after twenty years. Material that is both meaningful and greatly "over-learned" may stick almost indefinitely with little apparent loss. A student who had practiced on the typewriter for two hundred hours, and then

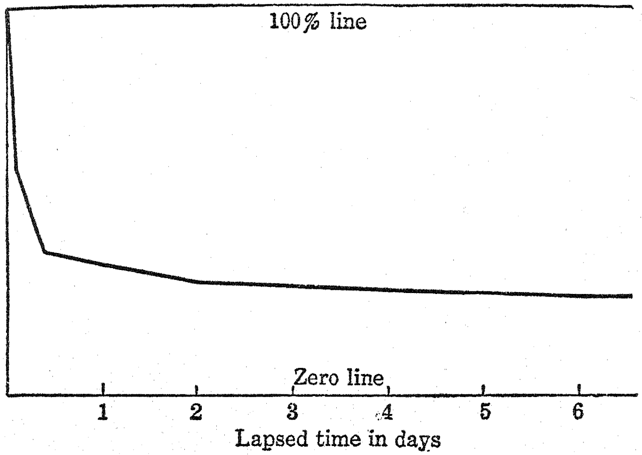


FIG. 7. — (From Ebbinghaus.) The curve of forgetting. The curve sinks at first rapidly, and then slowly, from the 100 percent line towards the zero line, 100 percent here meaning perfect retention, and 0 no retention.

dropped it entirely for a year, recovered all the lost ground in less than an hour of fresh practice, so showing a retention of over 99 percent.

How to retain. If the question is raised, how to avoid forgetting, the best answer is — Review. Each review gives the retention curve an upward shove, and the decline after each successive review is slower than before. Once the material is well learned, reviews spaced out at long intervals are sufficient to insure durable retention.

Very fortunately, the principles of economy of memorizing

hold good also for retention. Forgetting is slower when relationships and connections have been found in the material than when the learning has been by rote. Forgetting is slower after active recitation than when the more passive, receptive method of study has been employed. Forgetting is slower after spaced than after unspaced study, and slower after whole learning than after part learning.

An old saying has it that quick learning means quick forgetting, and that quick learners are quick forgetters. Experiment does not wholly bear this out. A lesson that is learned quickly because it is clearly understood is better retained than one which is imperfectly understood and therefore slowly learned; and a learner who learns quickly because he is on the alert for significant facts and connections retains better than a learner who is slow from lack of such alertness. The wider awake the learner, the quicker will be his learning and the slower his subsequent forgetting; so that one is often tempted to admonish a certain type of studious but easy-going person, "for goodness' sake not to dawdle over his lessons," with any idea that the more time he spends with them the longer he will remember them. More gas! High pressure gives the biggest results, provided only it is directed into high-level observation, and does not simply generate fear and worry and a rattle-brained frenzy of rote learning.

How to forget. The obvious answer, from what precedes, is, Don't review. Let what you want to forget atrophy through disuse. All of us who have studied a language, or any school subject, and dropped it with relief as soon as possible, can testify to the efficacy of this rule for forgetting. Loads and loads of uninteresting material, which we have known for a time, is cleared away by this mere passive process of forgetting through disuse. But is there anything more that one can do? Is there such a thing as "active forgetting." There are painful experiences that we should like to erase from memory,

especially experiences that hurt our pride and self-respect, and if psychology could show us any active way of killing these memories, we should like to use it. Some persons seem to have a way of violently *suppressing* such memories, and producing a genuine amnesia for them. It is a recall amnesia rather than a retention amnesia, however; the suppressed material, though inaccessible most of the time, may reappear under hypnosis or psychoanalysis, or in dreams or daydreams, or in a sort of trance or hysterical attack which these persons are liable to have from time to time. The process of suppression is not well understood, and psychology cannot tell the anxious inquirer exactly how to go about it. But so much as this is clear, that it is an abnormal sort of process, an unmanageable process which carries into the discard more than the subject means to lose. It may carry away much useful material that is associated with the painful experience; it may involve a loss of appetite, or a loss of the use of a hand, or the loss of the use of the eyes, just because these activities are tied up with the experience which is violently thrust out of memory. So this type of active forgetting is not to be recommended for general use. The very best rule for avoiding painful memories would be never to do anything you will be ashamed to remember. But this is a counsel of perfection. If we have become involved in something we shall hate to remember, the best rule is to face the facts, think them through, do what needs to be done (often other people have to be considered), and reach a satisfactory adjustment before laying the matter aside. In other words, complete your task, so that it shall not perseverate and you will not be forced to review it. Sew up the wound properly, and let time heal it.

RECALL

If anything has been learned, and is sufficiently retained, then it can be remembered — perhaps! There may be diffi-

culties in the recall or recognition process, especially in the recall process. In fact, recall sometimes balks even when the material is well retained. We know a person's name, as is proved by our recalling it later, but at the moment we cannot get it. We know the answer to an examination question, but in the heat and worry of the examination we give the wrong answer, and only later, too late, does the right answer come up. Some sort of inhibition or interference blocks recall in such cases.

One type of interference is emotional. Fear may paralyze recall. Anxious self-consciousness, or stage fright, has prevented the recall of many a well-learned speech, and disturbed many a well-practiced act. In any sort of public appearance, if you can avoid worry and self-consciousness, and go ahead confidently, absorbed in what you are doing, full of your subject, then you escape the emotional interference, and the ardor of the occasion may cause you even to surpass yourself in ease and fluency.

Another type of interference occurs when two acts are both aroused at the same time, and get in each other's way. You will sometimes hear a speaker hesitate and become confused because two ways of expressing his thought occur to him at the same instant. One recall blocks the other. Something of the same sort often happens when you start to recall a person's name. You get some other name which is more readily aroused at the moment, and, thus put off the track, labor in vain to reach the right name. Drop the matter, and a little later the desired name is recalled without trouble, because the interfering activity has quieted down and lost its temporary advantage. This plan of dropping the matter when one is baffled and confused, and taking it up again when fresh, works well in other cases besides hunting for a name. It often takes two sittings to solve a complex problem: in the first sitting you assemble your data, you study them from different angles, you get thoroughly acquainted with the whole situation — but

you can't see any way out. You seem to have got into a rut. So, being wise, you drop the matter till you can make a fresh start, when, the interferences awakened in the first, laborious sitting having quieted down, the whole matter may be perfectly clear.

Partial recall. When retention has become imperfect, through disuse, recall can be only partial at the best, but the interesting thing is that the performance is apt to be completed, somehow. Other sources are drawn upon to make a complete product, though recall is thus falsified.

For example, a name eludes us; we seem to have it in a general way, but it will not take definite shape. However, something does take definite shape, some complete name emerges, only it is not the name we want. It seems similar to the name we want, but we cannot tell exactly where the similarity lies, not make much use of the recalled name as a step towards the true name. When we do later ascertain the true name, it is interesting to lay it alongside of the name first recalled, and notice what similarity there is, if any. In the list of cases below, each line contains the name first recalled. followed by the true name that was sought.

Manning — Mayo
Bogert — Burgess
Macdonald — McDougall
Hennessy — Haggerty
Stoop — Cole
Ernst — Stern
Barclay — Clayton
Adleman — Wadleton
Balboa — Bonivard
Sonnenschein — Sonneborn
Kohlrausch — Rauber-Kopsch
Underwood — Overstreet
Poseidon — Parmenides
O'Rourke — McCrea
Guy Lussac — Ives Delage

The initial sound of the true name is likely to be present in the recalled name, though not always in the first position. The number of syllables and the accent are usually preserved. And the language or nationality of the name is usually preserved. Often, of course, recall is very prompt and easy, but in these cases where it is impeded, it seems to revive first the general character of the name, and then to get off the track and hit upon some other name that has the advantage of greater familiarity or more recent use.

A still better experiment on partial recall is one with nonsense drawings, which are shown for a moment and reproduced from memory. The general shape of the drawing is more apt to be reproduced than the details. A drawing observed to resemble any familiar object is apt to be modified in recall in such a way as to be a better representation of the object. Details which made little impression on the observer drop out in recall, leaving the figure more compact and simple. We may put the matter in this way: Some facts about the object strike the observer more forcibly than others and are better retained; consequently, when the observer tries to recall the object, the barely observed facts drop out and the strongly observed facts are thus accentuated. Much the same is certainly true of the recall of events and experiences: the impressive facts stand out, less impressive facts disappear, and the whole story is smoothed off to fit what is clearly recalled; and all this quite apart from any emotional bias which might distort the experience. When such distortion occurs, along with the always-to-be-expected elimination of some facts, accentuation of others, and rounding off of the whole, the resulting memory may be very wide of the original events.

Recall of childhood experiences. Most experiences of early childhood seem to be forgotten before adult years, to judge from the meager result of casually trying to recall them. On the whole, the farther back you go in time, the fewer incidents

you can recall. You can recall more from the past year than from any preceding year, more from the years about the age of twelve than from those about the age of eight, and more from these than from the age of four, while from all the vivid experiences of very early childhood scarcely anything can be revived. The main reason must be a gradual loss of retention

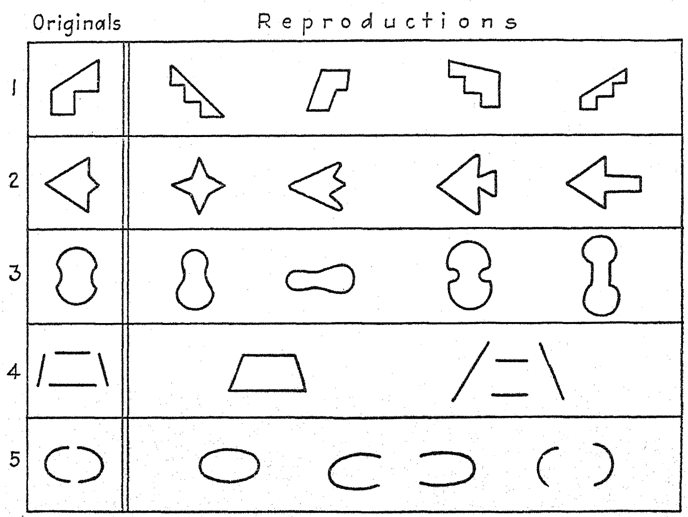


FIG. 8.—(From J. J. Gibson, 1929). Attempts to reproduce nonsense figures after a brief exposure of a series of fourteen of them. The left-hand column here shows some of the nonsense figures that were shown. The first one usually suggested stairs, but once a ship's ventilator. The second was seen as a star, as a bird flying, as an arrowhead, and as an arrow. The third was seen as a woman's torso, as a footprint, as a violin, and as a dumb-bell. In reproducing the broken figures, the subjects sometimes neglected the gaps, and sometimes overdid them.

with time and disuse, since what we learned at that early period and have continued to use, like the rudiments of language, we still get without difficulty. But few people make a point of keeping early memories alive by frequent review—think of the time it would consume!

However, more incidents can be recalled from childhood than

one would expect, if sufficient time is devoted to the search. Assemble all available cues, such as the few incidents you do readily recall, pictures and objects connected with your childhood, and statements made by people who knew you then, and then immerse yourself in this material, not so much making a strenuous effort to recall, as letting anything come up that will. You may be surprised to find how much does come up, but at the same time it remains very meager in comparison with the wealth of experiences you must have had in childhood.

Several special devices have been employed for assisting the subject to revive early memories, all of them aiming to put him into a relaxed and half-dreamy state. Hypnotizing him is one such device; another is crystal gazing (having him stare abstractedly into a glass ball), and another is automatic writing, which consists in letting the hand write without conscious control and without paying attention to what is being written. You ask your subject questions bearing on his childhood, and he replies in automatic writing, or sees pictures in the crystal; and, though he may not recognize the incidents thus brought to light as his own experiences, testimony from parents may verify them. Such probing has been attempted, of late, in the hope that revival of early memories would afford the means for correcting abnormal fears or other unfortunate twists in the personality that are supposed to date from early childhood; but the result so far cannot be said to be at all conclusive.[3]

The process of recall. Recall consists in doing now what you learned to do before. The " doing " may consist in reciting a poem or lesson of any sort, or it may consist in executing a skilled hand movement, or it may consist in those more intangible but none the less genuine forms of activity which we call seeing, hearing, understanding, etc. Learning, we said

[3] References: A. M. Muhl, *Journal of Abnormal Psychology*, 1924, vol. 19, pp. 264–273. William Ellery Leonard, *The Locomotive God*, 1927.

before, consists in doing and observing, the observing being a kind of doing. You observe a fact, and thereby learn it; later you recall the fact. Recalling is not wholly the same as observing, for in observing you have the fact presented to your senses, and your eyes or ears take part in the activity, while you recall the fact without having it before you. The recall process is not wholly the same as the observing process, but it is the same to this extent, that in both you get the same fact. Recall, then, may consist in reviving only a part of the activity that occurred in learning. Indeed, if the whole activity of learning needs to be revived, that is relearning, not recall. Learning, which may itself be very tortuous and laborious, results in the organizing of a relatively easy and straightforward action; retention consists in preserving the machinery for this action more or less intact; and recall consists in putting this machinery into motion again, and so going through the action prepared in the learning process.

The cue or stimulus to recall. If retention is a resting condition of machinery prepared in the process of learning, and if recall is an active condition of this machinery, we have to ask what sets the machinery in action. If you have memorized Hamlet's soliloquy, what is your cue to recite it now? Well, the words "Hamlet's soliloquy," or the idea expressed in those words, may be a sufficient cue to start you on the first line, and then each line or group of lines may be the cue for the lines next in order. If you have memorized a set of paired associates, either word of a pair may be cue enough to call up the other. If you have connected a person's face and his name, the face calls up the name, or the name the face.

The "cue," in this sense, is an instance of what is called in psychology a *stimulus*. A stimulus is whatever arouses the individual to any activity. A *response* is any activity aroused by a stimulus. Irritation in the throat is a stimulus, and coughing the response. A tap on the patellar tendon, just

below the kneecap, is a stimulus, and the knee jerk is the response. Light falling into the eye is a stimulus, and the sensation of light is the response, or part of the response. A person's face, appearing before us, is a stimulus, and the recall of his name is a response to this stimulus.

The whole mass of stimuli acting on an individual at any time makes up the *situation* that confronts him, and what he does is his response to the situation.

Now in recall the individual does something that he has previously learned to do; he makes a response that he has previously learned to make. But the situation to which he now responds is different in important respects from the situation confronting him when he learned this response. When he learned a poem, he had it before him to read, but now he recites it without the book. Yet there must be *some* stimulus present now that was present during the learning, something to take the place of the book. Let us see. At a given moment in the process of memorizing, the learner was reading certain words, and at the same time he had in mind the context of those words. After he had learned the poem, the context was enough, without the book before him, to call up those same words; and so on through the poem. *Part* of the original situation — here the context of a passage — recurring, is a sufficient stimulus for recall. An activity, such as repeating a line of the poem, originally aroused by a combination of stimuli — printed words plus context — can now be aroused by a part of this combination in the absence of the rest. Recall, then, consists in doing something now that we learned to do before, and in doing it with only a fraction of the situation present that was necessary at first to arouse and control this activity.

In Hollingworth's words,[4] "the essential fact in learning may be described as the reduction of the stimulus leading to a response." Learning reduces the cues necessary to arouse

[4] *Psychology: Its Facts and Principles,* 1928, p. 198.

an action, and the more complete the learning, the more is the cue reduced. Recall, then, is the arousing of an action by a reduced cue.

RECOGNITION

The same questions that we have been trying to answer regarding recall we should now ask regarding recognition. What sort of activity is recognition, and how is it aroused? What is this type of response, and what is its stimulus? And why is recognition easier than recall?

Just because recognition is quick and easy, it is elusive when we try to describe it; and here, as usual, our best chance for success will lie in cases where the process is not so easy or where it goes wrong.

Direct and indirect recognition. Odors have been used in experiments on recognition, just because they are not, as a rule, so easily and quickly recognized as are objects seen or heard. A theory to be tested in these experiments held that recognition was accomplished by the recall of the original setting of the odor in some past experience. A certain odor might recall to mind a mountain-side, and so lead to its recognition as the odor of a mountain flower. This indirect type of recognition does occur, but seems to be much less common than the direct sort, in which the odor is known before recall of the past experience has time to take place. Therefore, the theory mentioned cannot be accepted as a general description of the process of recognition.[5]

Partial recognition. Sometimes recognition is slow, and attended by curious feelings. You see some one who looks familiar, and feel that you must have seen him before. This "feeling of familiarity" haunts you till you can remember more about him. The person may seem to you, not simply familiar, but as if you had seen him recently, or a long time ago, at the seaside or some particular kind of place, or as if you

[5] Gamble and Calkins, *Zeitschrift für Psychologie,* 1903, vol. 32, p. 177.

had been amused by him, or looked up to him, or been on your guard against him, or bought something of him, etc. Such impressions often turn out to be correct, and they amount to partial recognition. The attitudes of amusement, deference, hostility, etc., revived in partial recognition were originally aroused by the individual as he conducted himself in a certain setting. When we later see the person apart from all the rest of the original situation, some of our original response is awakened. To judge from such cases, the response in recognition may be the revival of any attitude or other response formerly aroused by the object now recognized; and the stimulus to recognition may be but a fragment of the situation which originally aroused this response, so that recognition, as well as recall, gets along with much " reduced cues."

Errors of recognition. Though recognition is typically easy, it is not infallible by any means. If an object now presented resembles one seen before, there may be hesitation and error — reduced cue again, here working too well. In a recognition experiment, a series of pictures may be shown, one after another, and then intermingled with other pictures, some of which are quite similar to those shown, while others are very different, and the whole mixed lot is now shown to the subject, one picture at a time, and he is to say " Yes " to those he recognizes and " No " to those that seem new. He says " Yes " to many of those that are similar to what he saw before, and even to a few of those that are very different from any he saw before, but these false recognitions are likely to be slow and lacking in confidence. He also makes errors of the reverse kind, by failing to recognize pictures that were actually shown him before, and this sort of false response also is slow and doubtful, on the whole. The correct recognitions, on the other hand, are usually quick and confident. But the quickest and surest responses of all are the " No " responses to the new pictures. An important fact, this, for the psychology of recog-

nition. Non-recognition, or the knowing of a thing to be new, is not a mere absence of recognition, but is a quick, definite, emphatic action. A person suddenly confronted by an object is like a balance that can be tipped either way — either over to the recognition side or to the side of non-recognition.[6]

To make sure of later recognition of an object now before you, you need to make some distinctive response to it now, such as, for example, to note very definitely something about it that makes it different from other objects with which it might be confused. Ordinary casual observation of faces is not enough to insure recognition later. In the studies of errors of testimony, already spoken of, the identification of persons only casually observed has been found extremely unreliable.

Disorders of recognition. A total situation, in strictness, should never be recognized, for even if all externals are now the same as on some former occasion, you yourself have changed. You may be sitting in the same room, with the same furniture, same lighting, same temperature, same clothes on, and may even be re-reading the same book. But in the back of your head you are keeping in touch with your life in general, so that, though everything around is familiar, the total situation is new and felt to be new. That is the normal state of affairs. But sometimes, when one is in a let-down state, and far from alert and keen, even a decidedly novel situation or happening arouses the feeling of familiarity, a weird feeling that one has been through all this before, as if time had slipped a cog and were now repeating itself. Perhaps fifty per cent. of young people can remember having had this queer experience, and some few individuals suffer from it a great deal. It may be called the "illusion of having been there before."

The opposite illusion, called the "feeling of strangeness," also occurs in some abnormal conditions. The subject may use familiar articles well enough, and may be able to call the

[6] G. H. Seward, *Archives of Psychology*, 1926, No. 99.

names of his family and friends, but he insists that people, places and objects all seem new and strange to him, and naturally enough he is much disturbed. A full explanation of these illusions of recognition is not known, but one might imagine that the "balance" spoken of a moment ago had become disturbed so as always to tip the same way, in one person towards the familiarity response, in another towards the novelty response.

Recognition compared with recall. One difference becomes clear as soon as we notice how the two words are applied. We recognize something that is there, we recall something that is not there. What we recognize is given, needing only to be identified, but what we recall has to be found. It is the stimulus, then, that is recognized, while it is the response that is recalled.

The baby smiles at a person who has pleased him before, and shrinks from one who has displeased him, and thus shows recognition of both. The same can be said of the dog who barks at the door bell, though his mouth waters at the dinner bell. The learning process behind these recognitions consists not in learning to smile, shrink, bark, or secrete saliva, but simply in tying these responses to certain stimuli; and the recognition process may consist simply in reviving these responses to these objects. According to this conception, a stimulus is recognized if it recalls, or re-arouses, a response that was previously attached to that stimulus by a process of learning. The baby's smile was first attached to a certain person when that person was doing something to please him. Later, the baby shows recognition by smiling as soon as the person appears, without waiting for anything amusing. If the baby waited for the original combination of stimuli to recur before smiling, the smile would be no evidence of recognition, or of retention from the previous experience, or of any learning during that previous experience. The learning process

reduced the cue or stimulus for smiling, and the recognition consists in the arousing of the smile by this reduced stimulus. Now the smile itself may come to be reduced, so that when an adult suddenly encounters a person who sometime amused him, he feels the attitude of amusement within himself and thus (partially, if not completely) recognizes the person, without the necessity of openly grinning in his face.

According to this theory, recognition consists in the recall, or revival, of some response that was attached to the recognized object in some previous experience. In one case, recognition of a person may consist in reviving an attitude of amusement, or of hostility, but in another case it may consist in recalling the person's name. Recognition of a place may consist in feeling at home there, or in knowing your way about there, that is to say, in a readiness to behave as you formerly learned to behave in that place.

Why then, according to this theory, is recognition easier than recall? When you wish to recall anything, you have to recall one special thing — your cue has to arouse one particular response, or else you fail. But, to recognize an object, it is enough that your cue should arouse *any* response formerly attached to that object. You have much more leeway, and greater chances of success.

This theory of recognition needs to be supplemented by bringing in the definite response to a new object. An object may arouse the novelty response, or the familiarity response, the latter consisting in any sort of activity that has been attached to the object. The whole theory, though far from proved, may be of service in binding together the known facts of recognition, and in relating recognition to recall and to learning.

MEMORY IMAGES

We have been considering, in effect, the question of *how* we remember, and should turn for a moment to the companion

question of *what* we remember. The answer would seem to be, Anything whatever, provided only it has been learned and retained. A large share of what human beings recall or recognize consists of facts learned by observing them; and it is probably safe to say that any sort of fact that can be observed can be recognized when it is presented again, or recalled when a sufficient cue is given. Not everything that is observed is actually recalled or recognized, but probably there is no class of facts that is incapable of recall or recognition.

Consider, for example, the way things look, or sound, or taste, or smell, or the way they feel when you handle them. Can you recall the blue of the sky, or the tone of the violin or of a friend's voice, or the odor of camphor, or the feel of a lump of ice in the hand, or the way it feels to jump, or kick, or yawn, or clench your fist? Almost every one will answer "Yes" to some or all of these questions. One will report getting a vivid picture of a scene, and another a realistic mental rehearsal of a piece of music. What they recall seems to them essentially the same as an actual sensory experience.

A recalled fact that has much the same character as an actual sensation is called a memory image, or sometimes a mental image. Memory images, then, are recalled sensations, or have more or less of the quality of sensations.

Individuals seem to differ greatly in the vividness or realism of their memory images. Galton, in taking a census of mental imagery, asked many persons to call up the appearance of their breakfast table as they had sat down to it that morning, and to notice how lifelike the image was, how complete in details, how adequate in color, how steady and lasting, in comparison with the actually present scene. Some individuals reported that the image was in all respects the same as an original sensation — as bright, as colorful, as complete, as steady — while others denied that they got anything resembling actual sensation, though they could perfectly well recall defi-

nite facts that they had observed regarding the breakfast table. The majority of people gave reports intermediate between these extremes.

The question of "imagery types." Not only do individuals differ in the vividness or realism of their memory images, but they also differ in the *modality* of their images, i.e., the sense from which most of their images are derived. Some who have little success in recalling images from the sense of sight can recall sounds easily, and others who have little of either visual or auditory imagery do get images from the kinesthetic sense, the sense of bodily movement. In thinking of a word, some persons see it, some hear it, some feel it in their mouth and throat. When this difference between individuals was first discovered, a very pretty theory of "types" was based upon it. Every individual, the theory ran, belonged to one or another distinct type; either he was a "visualist," thinking of everything as it appears to the eyes, or he was an "audile," thinking of everything according to its sound, or he was of the kinesthetic type, or, in rare cases, he might belong to the olfactory or the gustatory or the skin-sense type.

But the progress of investigation showed, first, that a "mixed type" must also be admitted, to provide for individuals who easily called up images of two or more different senses; and, second, that the mixed type was the most common. In fact, it is now known to be very unusual for an individual to be confined to images of a single sense. Nearly every one runs predominantly to visual images, yet nearly every one also has, from time to time, images of sound, smell, touch, and bodily movement. So that the individual of mixed type is the only really typical individual, the extreme visualist or audile being the exception and not the rule.

This giving up of the doctrine of types of individual, in the case of imagery, merits our careful attention, for the reason

that "types" of one sort or another are constantly being proposed by some student of individual differences. In comparing individuals, we are naturally struck by the extreme cases that differ widely from each other, and then we slide into regarding these extremes as opposed types of individual, and try to classify all people under one or the other of our divergent types. But we soon find individuals who resist such classification, because they lie halfway between our extreme types, and so we begin to speak of a "mixed type." But if we continue our study, we finally see that most individuals belong to our mixed type or average, some deviating from the average more or less toward the one extreme, and some toward the other. Individuals differ in degree rather than in kind, and are distributed about an average in the way that we noticed in studying intelligence, rather than being divided into separate classes or types.

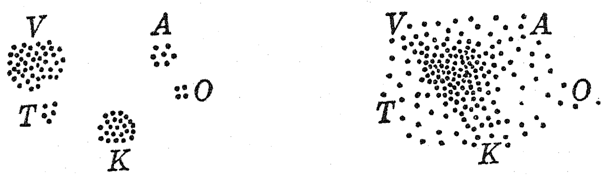


FIG. 9.—Individual differences in mental imagery. According to the type theory, every individual has a place in one or another of the distinct groups, visual, auditory, tactile, kinesthetic, or auditory. According to the facts, the majority of individuals cluster in the middle space, and form a single large group, though some few are extremely visual, or auditory, etc., in their imagery.

Images are limited to facts previously observed. Most images are inferior in realism and in completeness to actual sensory experience. And they are specially inferior to the actual presence of the object, in that we cannot utilize the image as a source of new information. We cannot observe facts in the image of a thing that we have not observed in the actual presence of the thing.

At one of the universities, there is a beautiful library building, with a row of fine pillars across the front, and the students pass this building every day and enjoy looking at it. A favorite experiment in the psychology classes at that university consists in first asking the students to call up an image of the front of the library, and then asking them to count the pillars from their image. But at this point the students begin to object. "We have never counted those pillars, and cannot be expected to know the number now." In fact, few of them give the correct number, and those whose images are vivid and realistic are little better off in this respect than those whose images are dim and vague.

Ordinarily, in looking at a beautiful building, we simply take in the general effect; and when we later get an image of the building, it is just this general effect which we recall. If we pick out details in looking at the building, we can later recall them. If we study the color scheme, or the balance of masses, while looking at the building, we can recall what we have observed and no more. Many facts which can be observed in the presence of an object are abstract, in the sense that they could not exist by themselves, but only as embodied in a concrete whole possessing many properties which we do not particularly notice. Patterns and relationships which could not exist by themselves in reality, may be singled out for observation, since they are often the interesting or important facts to know. These abstract characteristics of objects, though they cannot exist by themselves, can be recalled by themselves, or with only a vague background of the concrete object. So your recall of the breakfast table, or of any experience, while as a picture it may be very lacking in realism, may contain the important facts which you noted at the time. The raw materials, which recall furnishes for thought to work with, consist of all varieties of facts observed when we have the objects before us. In thinking or imagining or inventing,

we put together facts observed at different times, and now assembled by the process of recall.

The primary memory image — eidetic images. What has been said of images, so far, refers to recall from the resting state of retention some time after the original experience. The primary memory image, if it is a memory image at all, is different in that the experience has never lapsed into the resting state, but is simply persisting for a few moments after the original stimulus has ceased. For a few seconds after somebody has stopped talking, you can still get the sound of his voice, as if in an echo, even though you usually cannot recall sounds with any distinctness. You may be able to recover what he has said, and get a question that he has asked, though you were not closely attending to it at the instant when he was speaking. In the same way, immediately after you have looked over the landscape out of your window, you can still see it better than you can recall it later. This primary memory image is not the same as the "after-image" or after-sensation to be described later under the head of sensation. But the primary memory image differs from the recalled memory image in presenting more sensory detail and permitting details to be observed that were not observed during the actual sensation.

Now it appears that a large proportion of children under fourteen years of age, perhaps half of them, if they examine any complex object or picture in an absorbed way for half a minute, and then shut their eyes, or, still better, turn them upon a plain gray background, can actually *see* the object there, almost as if it were still before them, and can answer questions about it which they did not have in mind during the actual presence of the object. However, this image is not strictly photographic, but rather plastic, and likely to be modified by the subject's interest. The interesting object may grow larger, or may become more regular, or may appear to move if it is an object that suggests motion. The color may become

more brilliant, or may change to quite a different color. If there are several objects in the image, one of them may be removed while the others stay. Such changes may be either voluntary or involuntary. This type of image, then, is quite subjective, though on the whole it conforms rather closely to the scene from which it was taken.

These peculiarly vivid and detailed primary memory images have been called "eidetic images," and the individuals who have them "eidetic individuals." Eidetic imagery seems to be most common in later childhood, and to fade out, usually, during adolescence, though a few adults can still obtain images of this sort. Such images, though usually appearing, if at all, immediately after being immersed in the actual contemplation of an object, may perseverate and reappear later.[7]

Hallucinations. Since a vivid memory image may be "in all respects the same as an actual sensation," according to the testimony of some persons, the question arises how such an image is distinguished from a sensation. Well, the image does not usually fit into the objective situation present to the senses. But if it does fit, or if the objective situation is lost track of, then, as a matter of fact, the image may be taken for an actual sensation.

You see some beautiful roses in the florist's window, and you *smell* them; the odor fits into the objective situation very well, till you notice that the shop door is shut and the window glass impervious to odors, from which you conclude that the odor must have been an image after all.

You are half asleep, almost lost to the world, and some scene comes so vividly before you as to seem real till it awakens you to the reality of your surroundings. Or you are fully asleep,

[7] The work on eidetic images is mostly in German, but some convenient accounts in English are by H Klüver in Murphy's *Historical Introduction to Modern Psychology*, 1929, pp. 437–442, and by G. W. Allport in the *British Journal of Psychology*, 1924, vol. 15, pp. 99–120.

and then the images that come are dreams and seem entirely real, since contact with the objective situation has been lost.

Images taken for real things are common in some forms of mental disorder. Here the subject's hold on objective reality is loosened by his absorption in his own fears and desires, and he hears reviling voices, smells suspicious odors, or sees visions that are in line with his fears and desires.

Such false sensations are hallucinations. A hallucination is a memory image taken for a sensation, it is something recalled or built up out of past experience taken for a present objective fact.

Synesthesia. A considerable number of normal persons have the peculiarity of hearing sounds as if also having color, a deep tone sounding dark blue, it may be, a trumpet bright red. Each vowel and consonant may have its own special color, and a word may have a color scheme built up out of the colors of the letters. Numbers also are likely to have their colors. Colored hearing is the commonest, though not the only form of synesthesia, which consists in responding to a stimulus acting on one sense by sensations or images belonging to another sense. The synesthesia probably originated in childhood from playfully linking the different kinds of sensation together.

MEMORY TRAINING

The important question whether memory can be improved by any form of training breaks up, in the light of our previous analysis, into the four questions, whether memorizing can be improved, whether the power of retention can be improved, whether recall can be improved, and whether recognition can be improved. As to recognition, it is difficult to imagine how to train it; the process is so elusive and so direct. It has been found, however, that practice in recognizing a certain class of objects improves one's standards of judgment as to whether a feeling of familiarity is reliable or not; it enables one to dis-

tinguish between feelings that have given correct recognitions and the vaguer feelings that often lead one astray.

As to the process of recall, it too is rather unmanageable, but our previous discussion has brought out some points of practical value. The try-rest-try-again attack upon something which eludes recall is a technique that one can adopt with advantage. Trusting your memory is a favorable attitude for recall, much better, certainly, than an anxious doubt whether memory is not going to fail you, and this desirable confident attitude can be strengthened by making it a practice to rely upon your memory.

As to retention, since it is not a performance but a resting state, how could we possibly go to work to improve it? About all that can be suggested is to keep the brain in good physical condition, so that its retentiveness be not decreased from the level normal to the individual. For example, it is a good memory rule to avoid getting knocked on the head, for jarring may disturb old traces, as well as prevent the consolidation of newly formed connections. Continued dosage with alcohol sometimes produces a condition in which, while old memories and habits are largely retained, nothing new is registered. Retentiveness can be protected, then, by hygienic measures, but that is quite another thing from improving retentiveness by any form of training.

On the other hand, the process of committing to memory, being a straightforward and controllable activity, is exceedingly susceptible to training, and it is there, for the most part, that memory training should be concentrated in order to yield results. It does yield marked results. In the laboratory, the beginner in learning lists of nonsense syllables makes poor work of it. He is emotionally wrought up and uncertain of himself, goes to work in a random way (like any beginner), perhaps tries to learn by pure rote or else attempts to use devices that are ill-adapted to the material, and has a slow and tedious job

of it. With practice in learning this sort of material, he learns to observe suitable groupings and relationships, becomes sure of himself and free from the distraction of emotional disturbance, and may even come to enjoy the work. Certainly he improves greatly in speed of memorizing nonsense syllables. If, instead, he practices on Spenser's "Faery Queen," he improves in that, and may cut down his time for memorizing a twelve-line stanza from fifteen minutes to five. This improvement is due to the subject's finding out ways of tackling this particular sort of material. He gets used to Spenser's style and range of ideas. And so it is with any kind of material; practice brings great improvement in memorizing that particular material.

Whether practice with one sort of material brings skill that can be "transferred," or carried over to a second kind of material, is quite another question. Usually the amount of transfer is small compared with the improvement gained in handling the first material, or compared with the improvement that will result from specific training with the second kind. What skill is transferred consists partly of the habit of looking for groupings and relationships, and partly in the confidence in one's own ability as a memorizer. It is really worth while taking part in a memory experiment, just to know what you can accomplish after a little training. Most persons who complain of poor memory would be convinced by such an experiment that their memory was fundamentally sound. But these laboratory exercises do not pretend to develop any general "power of memory," and the much advertised systems of memory training are no more justified in such a claim. What is developed, in both cases, is skill in memorizing certain kinds of material so as to pass certain forms of memory test.

One who suffers from poor memory for any special material, as names, errands, or engagements, probably is not going to work right in committing the facts to memory; and if he

gives special attention to this particular matter, keeping tab on himself to see whether he improves, he is likely to find better ways of fixing the facts and to make great improvement. It was said of a certain college president of the older day that he never failed to call a student or alumnus by name, after he had once met the man. How did he do it? He had the custom of calling each man in the freshman class into his office for a private interview, during which, besides fatherly advice, he asked the man personal questions and studied him intently. He was interested in the man, he formed a clear impression of his personality, and to that personality he carefully attached the name. Undoubtedly this able scholar was possessed of an unusually retentive memory; but his memory for names depended largely on his method of committing them to memory.

Contrast this with the casual procedure of most of us on being introduced to a person. Perhaps we scarcely notice the name, and make no effort to attach the name to the personality. To have a good memory for names, one needs to give attention and practice to this specific matter. It is the same with memory for errands; it can be specifically trained. Perhaps the best general hint here is to connect the errand beforehand in your mind with the place where you should think, during the day, to do the errand.

Often some little *mnemonic system* will help in remembering disconnected facts, but such devices have only a limited field of application and do not in the least improve the general power of memory. Some speakers, in planning out a speech, locate each successive "point" in a corner of the hall, or in a room of their own house; and when they have finished one point, look into the next corner, or think of the next room, and find the following point there. It would seem that a well-constructed speech should supply its own logical cues so that artificial aids would be superfluous. In training the memory for the significant facts of one's business, the best rule is to

interrelate the facts into a system. The cross-connections between all the several items in the system provide plenty of good cues for the recall of any desired item.

In general, memory training consists in improved management of the learning process. Observant study, alive to patterns, relationships, meanings, and promising cues for later recall — economy of effort in learning, by use of recitation, spacing, and the best combination of whole and part study to fit the material in hand — these principles of good management indicate the field in which memory can be effectively trained. For the most part, successful memory training consists in improving the procedure and technique of learning.

EXERCISES

1. Outline the chapter in the following form: you have the four main topics of learning, retention, recall, and recognition; and under each list (1) the main facts, (2) theory, (3) applications.

2. Plot a curve of forgetting from the following data obtained by E. K. Strong with the recognition method. Each lesson consisted of 20 disconnected words, read once, and later shown again mixed with 20 new words, with instructions to pick out the words recognized as having been seen before in the experiment. The average results, from several subjects, were as follows:

Recognized at once				84%
"	after	1	hour	56%
"	"	2	hours	50%
"	"	4	"	47%
"	"	8	"	40%
"	"	12	"	38%
"	"	24	"	29%

(The score further decreased to 10% after seven days.)

3. An experiment to yield a learning curve. Before proceeding, take an opaque sheet of paper and cover up the short printed lines below. The plan is, after reading the material once through, to cover it all up and try to recall the first line, and if you succeed, write the number 1 at the right of this line. Try to anticipate each line in

order, marking 1 at the end of each line where you succeed. Then start at the top again, and proceed as before, but writing 2 (meaning "second trial") after each line where you succeed in anticipating before looking. So continue till you anticipate every line, i.e., till you recite the whole passage correctly. If you have kept tally correctly, counting the times the number 1 occurs shows your score on the first complete trial; the number 2 shows your score on the second trial, and so on. Plot the learning curve, showing graphically the score in each trial in order. Ready — Go!

A possible explanation
of the well known fact
that girls surpass boys
in school marks
is to the effect
that girls like school better
and are more in tune
with the teachers
and the whole situation.
But whether the girls
actually master
the school subjects
better than boys
cannot be told
from school marks alone,
since other factors
besides the child's achievement
are likely to affect
the teacher's marking,
as elsewhere in life.

4. Recall recent and remote experiences. Choose some type of experience that you have had repeatedly — as the family Christmas tree, or a birthday party — and recall the details of two such occasions, one much more remote in time than the other. By making a tally mark for each item recalled, you can obtain a rough numerical estimate of the fullness of recall of each experience.

5. Work out a scientific plan of attack upon a long lesson, the sense of which you wish to master thoroughly but with economy of time.

6. If you wished, like the subject of our case history in Chapter I, to have a store of people's ways of acting and talking ready in your

memory for use in writing stories, how would you proceed to create such a store?

7. Show how the "factor of recency" works sometimes to help and sometimes to hinder the accomplishment of a memory task.

8. How does emotional disturbance interfere with (a) memorizing, and (b) recall?

9. Recitation in memorizing meaningful material: (a) show some reason why the difference between continued re-reading and active recitation should be less important in learning connected passages than in learning nonsense or disconnected material; (b) if the task is, not to learn the meaningful material verbatim, but to remember the thought, how would you adapt "recitation" to fit the task?

10. The rating of images belonging under different senses. Try to call up the images prescribed below, and rate each image according to the following scale:

3. . . . The image is practically the same as a sensation, as bright, full, incisive, and, in short, possessed of genuine sensory quality.

2. . . . The image has a moderate degree of sensory quality.

1. . . . The image has only faint traces of sensory quality.

0. . . . No sensory image is called up, though there was a recall of the fact mentioned.

Call up visual images of: a friend's face, a sunflower, a white house among trees, your own signature written in ink.

Call up auditory images of: the sound of your friend's voice, a familiar song, an automobile horn, the mewing of a cat.

Call up olfactory images of: the odor of coffee, of new-mown hay, of tar, of cheese.

Call up gustatory images of: sugar, salt, bitter, acid.

Call up cutaneous images of: the feel of velvet, a lump of ice, a pencil held against the tip of your nose, a pin pricking your finger.

Call up kinesthetic imagery of: lifting a heavy weight, reaching up to a high shelf, opening your mouth wide, kicking a ball.

Call up organic imagery of: feeling hungry, feeling thirsty, feeling nausea, feeling buoyant.

In case of which sense do you get the most lifelike imagery, and and in case of which sense the least. By finding the average rating given to the images of each sense, you can arrange the

senses in order, from the one in which your imagery rates highest to the one in which it rates lowest. It may be best to try more cases before reaching a final decision on this matter.

REFERENCES

Ebbinghaus, *On Memory,* 1885, translated by Ruger and Bussenius, 1913, the pioneer experimental study of memory, is still well worth reading.

Among the numerous studies of special problems in memory, mention may be made of A. I. Gates, *Recitations as a Factor in Memorizing,* 1917, containing on pp. 65–104 an analysis of the devices employed by the memorizer; and of C. W. Luh, "The Conditions of Retention," *Psychological Monographs,* 1922, no. 142, who rechecks the Ebbinghaus curve of forgetting by several methods.

For unintentional learning and the reliability of testimony, see G. M. Whipple, *Psychological Bulletin,* 1918, vol. 15, pp. 233–248; also G. C. Myers, "A Study in Incidental Memory," *Archives of Psychology,* 1913, no. 26.

Francis Galton's original study of imagery is contained in his interesting *Inquiries into Human Faculty,* 1883.

CHAPTER IV

LEARNING

Various

VARIOUS FORMS OF LEARNING COMPARED, WITH THE OBJECT OF FINDING GENERAL LAWS OF LEARNING

After all our studies of memory, with all the experiments on conditions favorable for memorizing, and all our efforts to fathom the underlying processes, it might seem that we already possessed information enough to justify us in formulating our laws of learning. But there is a whole mass of further information, derived from studies of the learning of various performances by men and animals, and we need all the light we can get both on the apparently simple question of *what* is learned, and on the obviously intricate question of *how* it is learned. The *how* question breaks up into two, as already suggested: the question of the *conditions* favorable to learning, and the question of the fundamental *process* of learning. As different types of learning are passed in review, the main object will be to get ready to answer these questions.

THE LEARNING OF COMPLEX ACTION PATTERNS

A great deal of light has been thrown on the learning process by psychological studies of the course of improvement in mastering such trades as telegraphy and typewriting.

A student of telegraphy was tested once a week to see how rapidly he could send a message, and also how rapidly he could "receive a message off the wire," by listening to the clicking of the sounder. The number of letters sent or received per minute was taken as the measure of his proficiency. This

number increased rapidly in the first few weeks, and then more and more slowly, giving a typical learning curve, or "practice curve," as it is also called.

The curve for sending, aside from minor irregularities, rose with a fairly smooth sweep, tapering off finally towards the "physiological limit," the limit of what the nerves and muscles of this individual could perform.[1] The receiving curve rose

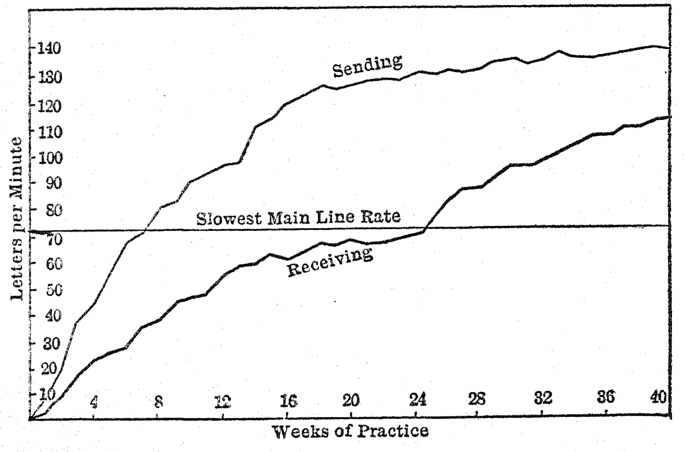


FIG. 10. — (From Bryan and Harter.) Practice curve of student W. J. R. in learning telegraphy. The height of the curve indicates the number of letters sent or received per minute. Therefore a rise of the curve here indicates improvement.

more slowly than the sending curve, and flattened out after about four months of practice, showing little further improvement for the next two months. This was a discouraging time for the student, for it seemed as if he could never come up to the commercial standard. In fact, many learners drop out at this stage. But this student persisted, and, after the long

[1] A good example of the physiological limit is seen in the hundred yard dash, since apparently no one, with the best of training, can lower the record much below ten seconds; and any given individual's limit may be considerably worse than this, according to his build, muscular strength and quickness of nerve centers.

period of little improvement, was gratified to find his curve going up rapidly again. It went up rapidly for several months, and when it once more tapered off into a level, he was well above the minimum standard for regular employment.

Such a flat stretch in a practice curve, followed by a second rise — such a period of little or no improvement, followed by rapid improvement — is called a "plateau." Sometimes due to mere discouragement, or to the inattention that naturally supervenes when an act becomes easy to perform, it often has a different cause. It may, in fact, represent a true physiological limit for the act as it is being performed, and the subsequent rise to a higher level may result from *improved methods* of work. That was probably the case with the telegrapher.

The telegrapher acquires skill by improving his methods, rather than by simply speeding up. He acquires methods that he didn't dream of at first. At the start, he must learn the dots and dashes. This means, for purposes of sending, that he must learn the little rhythmical pattern of finger movements that stands for each letter; and, for purposes of receiving, that he must learn the rhythmical pattern of clicks from the sounder that stands for a letter. When he has learned the letters, he is able to send and receive slowly. In sending, he spells out the words, writing each letter as a separate act. In receiving, at this early stage, he must pick out each separate letter from the continuous series of clicks that he hears from the sounder. By degrees, the letters become so familiar that he goes through this spelling process easily, and supposes that he has learned the trade, except that he has to put on more speed.

But not at all! He has acquired but a small part of the necessary stock-in-trade of the telegrapher. He has his "letter habits," but knows nothing as yet of "word habits." These gradually emerge as he continues his practice. He comes to know words as units, motor units for sending purposes, auditory units for receiving. The rhythmical pattern

of the whole word becomes a familiar unit. Short, much used words are first dealt with as units, then more and more words, till he has a large vocabulary of word habits. A word that has become a habit need not be spelled out in sending, nor laboriously dug out letter by letter in receiving; you simply think the word "train," and your finger taps it out as a connected unit; or, in receiving, you recognize the characteristic pattern of this whole series of clicks. When the telegrapher has reached this word habit stage, he finds the new method far superior, in both speed and sureness, to the letter habit method which he formerly assumed to be the whole art of telegraphy. He does not even stop with word habits, but acquires a similar control over familiar phrases.

Higher units and overlapping. The acquisition of skill in telegraphy consists mostly in learning to use these higher units, combinations, or action patterns. It is the same in typewriting. First you learn your keyboard. If you are going to work methodically, by the "touch method," without using the eyes to find the keys, you adopt a standard resting position for the hands on the board, and learn which finger to use for each letter, and so you soon learn your alphabet of letter-striking movements. By degrees you reduce each finger movement to an automatic habit, and then you have reached the letter-habit stage, in which you spell out each word as you write it. After a time, you write a familiar word without spelling it, by a coördinated series of finger movements; you write by word units, and later, in part, by phrase units; and these higher units give you speed and accuracy.

Along with this increase in the size of the reaction-units employed goes another factor of skill that is really very remarkable. This is the "overlapping" of different reactions, a species of doing two or more things at once, only that the two or more reactions are really parts of the same total activity. The simplest sort of overlap can be illustrated at an early stage

in learning to typewrite. The absolute beginner at the typewriter, in writing "and," pauses after each letter to get his bearings before starting on the next; but after a small amount of practice he will locate the second letter on the keyboard while his finger is still in the act of striking the first letter. Thus the sensory part of the reaction to the second letter commences before the motor part of reacting to the first letter is finished; and this overlap does away with pauses between letters and makes the writing smoother and more rapid.

With further practice in typewriting, when word habits and phrase habits are acquired, overlap goes to much greater lengths. One expert kept her eyes on the copy about four words ahead of her fingers on the keyboard, and thus was reacting to about four words at the same time: one word was just being read from the copy, one word was being written, and the two words between were being organized and prepared for actual writing. The human typewriting mechanism, consisting of eye, optic nerve, parts of the brain and cord, motor nerves and muscles, works somewhat like one of those elaborate machines which receive raw material steadily at one end, perform a series of operations upon it, and keep turning out finished product at the other end.

All this is very remarkable, but the same sort of overlapping and working with large units can be duplicated in many linguistic performances that every one makes. In reading aloud, the eyes keep well ahead of the voice, and seeing, understanding and pronouncing are all applied simultaneously to different words of the passage read. In talking, the ideas keep developing and the spoken words tag along behind.

In telegraphy and typewriting, it is almost inevitable that the learner should begin with letters and reach the higher units later. But in learning to read, the process may go the other way, and most children can better be taught to read by starting with whole words, or even with whole phrases, than

by first learning the alphabet and laboriously spelling out the words. In short, the learning process often masters the higher units first, and proceeds to the smaller elements only for the purpose of more precise control.

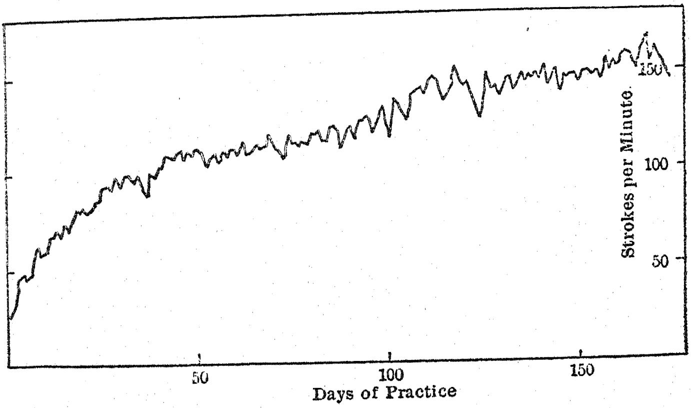


FIG. 11. — (From Book.) Practice curve of a young man learning to typewrite. Each point on the "curve" represents a daily record in number of strokes per minute. With improvement, the curve rises.

Moderate skill acquired in the ordinary day's work. Merely repeating a performance many times does not give the high degree of skill that we see in the expert telegrapher or typist. Ordinarily, we practise much less assiduously, are much less zealous, and have no such perfect measure of the success of our work. For "practice to make perfect," it must be strongly motivated, and it must be sharply checked up by some index or measure of success or failure. If the success of a performance can be measured, and chalked up before the learner's eyes in the form of a practice curve, so that he can see his progress, this acts as a strong incentive to rapid improvement.

Ordinarily, we have no clear indication of exactly how well we are doing, and are satisfied if we get through our job easily and without too much criticism and ridicule from people around. Consequently we reach only a moderate degree of

skill, nowhere near the physiological limit, and do not acquire the methods of the real expert.

This is very true of the manual worker. Typesetters of ten or more years' experience were once selected as subjects for an experiment on the effects of alcohol, because it was assumed that they must have already reached their maximum skill. In regard to alcohol, the result was that this drug caused a falling off in speed and accuracy of work — but that is another story. What we are interested in here is the fact that, as soon as these experienced operators found themselves under observation, and their work measured, they all began to improve and in the course of a couple of weeks reached quite a new level of performance. Their former level had been reasonably satisfactory under workaday conditions, and special incentive was needed to make them approach their limit. A similar condition of affairs has been disclosed by " motion studies " of many kinds of manual work. When the movements of an operative are photographed or closely examined by the efficiency expert, superfluous motion is usually found, and considerable economy of effort seen to be possible. There is evidently no law of learning to the effect that continued repetition of a performance necessarily makes it perfect in speed, ease, or adaptation to the task in hand. What the manual worker attains as the result of prolonged experience is a passable performance, but not at all the maximum of skill.

The brain worker has little to brag of as against the manual worker. He, too, is only moderately efficient in doing his particular job. There are brilliant exceptions — bookkeepers who add columns of figures with great speed and precision, students who know just how to put in two hours of study on a lesson with the maximum of effect, writers who always say just what they wish to say and hit the nail on the head every time — but the great majority of us are only passable. We need strong incentive, we need a clear and visible measure of suc-

cess or failure, we need, if such a thing were possible, a practice curve before us to indicate where we stand at the present moment with respect to our past and our possible future.

The main thing to be gathered from these studies of skill, for the purpose of getting an adequate picture of the learning process, is that *what* we learn includes such a thing as a higher unit, a combination of simple movements into an organized action pattern. How this is accomplished remains rather a mystery, but at any rate we have a fact in our possession that needs to be accounted for in any complete theory of learning.

MAZE LEARNING BY ANIMALS AND MEN

We now begin to make some use of animal psychology. Animals do learn. The higher animals learn much, and even the lowest, unicellular animals have some rudimentary power of learning. The fact that all animals learn less than men, and often more slowly, makes them good subjects for the study of the learning process. The slower and simpler the process, the easier it is to follow. Mere anecdotes of intelligent behavior in animals are of little value, but experimental studies, in which the animal's progress is followed, step by step, from the time when he is confronted by a novel situation till he has mastered the trick, furnish some of the best information to be had on the subject of learning.

Lloyd Morgan's canon for the interpretation of animal behavior. Lloyd Morgan, one of the founders of modern animal psychology, laid down,[2] in 1894, a principle which has commended itself to nearly all the hard-headed students of animal behavior who have labored since that date. As he put it: "In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty, if it can be interpreted as the outcome of the exercise of one which stands lower in the psychological scale." This means, for example, that we are

[2] C. L. Morgan, *An Introduction to Comparative Psychology*, 1894, p. 53.

not justified in explaining the animal's solution of a problem as due to a process of reasoning, if it can possibly be explained as the result of simply trying one thing after another till something works. It means that we should not attribute foresight and purpose to the animal, if his behavior can possibly be understood as driven by hunger, or thirst, or some other organic need. It means, in general, that we should avoid "anthropomorphism," or the reading of human characteristics into animal behavior. We lose the scientific value of the simpler types of behavior if we immediately interpret them as complex. One reason for the canon is that we know from human experience that the more elaborate, intellectual handling of a situation is not likely to occur except where it is forced upon us by the failure of simpler lines of attack. If we get rid of a difficulty by a little trying of this and that, we are not likely to reason out the principles involved. How many of us have learned to use the telephone, or the radio, or the automobile, by understanding the principles involved? It must be admitted, however, that Lloyd Morgan's canon is not always a clear guide, for we are not always sure which is the higher and which the lower of two forms of activity. Which is the lower and more rudimentary activity, seeing an object that is before us, or reaching out and moving it? In short, whether animal learning depends entirely on the motor activity of the animal, or whether rudimentary observation of facts is also involved, remains an open question, in spite of the canon.

The white rat in the maze. An animal is placed in an enclosure from which it can reach food by following a more or less complicated path. The rat is the favorite subject for this experiment, but it is a very adaptable type of experiment and can be tried on any animal. The rat, placed in a maze, explores. He sniffs about, goes back and forth, enters every passage, and actually covers every square inch of the maze at least

once; and in the course of these explorations hits upon the food box. Replaced at the starting point, he proceeds as before, though with more speed and less dallying in the blind alleys. On successive trials he goes less and less deeply into a blind alley, till finally he passes the entrance to it without

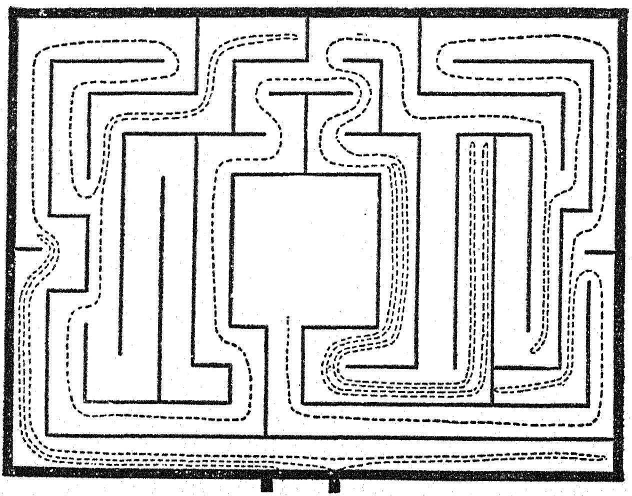


FIG. 12. — (From Hicks.) Ground plan of a maze used in experiments on the rat. The central square enclosure is the food box. The dotted line shows the path taken by a rat on its fourth trial, which occupied 4 minutes and 2 seconds.

even turning his head. Thus eliminating the blind alleys one after another, he comes at length to run by a fixed route from start to finish.

At first thought the elimination of useless moves seems to tell the whole story of the rat's learning process; but careful study of his behavior reveals another factor. When a rat that has already learned a particular maze approaches a turning point in it, he sweeps to the outside and goes around in a wide curve; he does not simply advance step by step to the cor-

ner and then start his turn, but several steps before he reaches the corner are organized into a pattern or higher unit.

The presence of higher units in the rat's learned behavior is shown also by a certain variation of the experiment. It is known that the rat, after learning a maze, makes much less

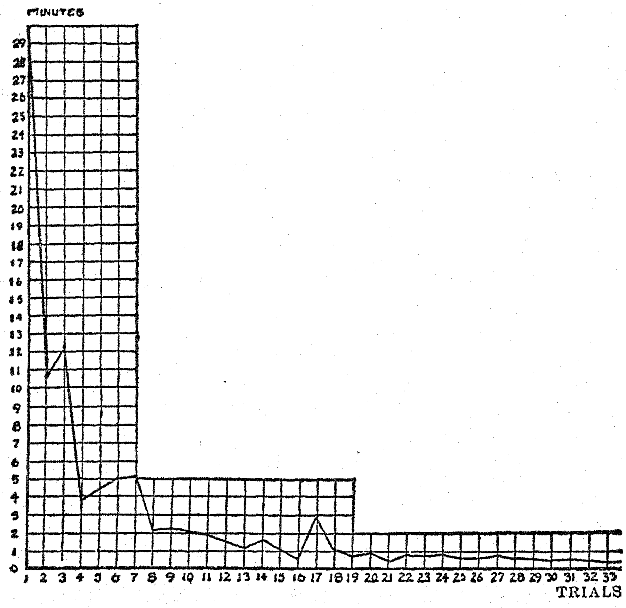


FIG. 13. — (From Watson.) Learning curve for the rat in the maze. This is a composite or average, derived from the records of four animals. The height of the heavy line above the base line, for any trial, indicates the number of minutes consumed in that trial in passing through the maze and reaching the food box. The gradual descent of the curve indicates the gradual decrease in time required, and thus pictures the progress of the animals in learning the maze.

use of the sense of sight in running it than a human being would. Now if the maze, after being well learned, is altered by shortening one of the straight passages, the rat runs full tilt against the new end of the passage, showing clearly that he was proceeding, not step by step, but by *runs* of some length.

What we see in the rat's maze learning, then, is exploration at the start, motivation by the food, gradual elimination of superfluous movements, and the combination of the remaining movements into smooth-running action patterns.

Human children and adults in the maze. An enlargement of the rat maze is employed with human subjects, in order to make possible a direct comparison of human and animal procedure in learning the same maze. The human subject has an initial advantage from knowing he is in a maze and has to master it, while the rat knows no more than that he is in a strange place, to be explored with caution on the odd chance that it may contain something eatable, or something dangerous. But, after once reaching the food box, the rat begins to put on speed in his movements, and within a few trials is racing through the maze faster than the adult man, though not so fast as a child. Adults are more circumspect and dignified, they make less speed, cover less distance, but also make fewer false moves and finish in less time. That is in the early trials; adults do not hold their advantage long, since children and even rats also reach complete mastery of a simple maze in ten or fifteen trials.

The chief point of superiority of adults to human children, and of these to animals, can be seen in the adjacent table. It is in the *first trial* that the superiority of the adults shows most clearly. They get a better start, and adapt themselves to the situation more promptly. Their better start is due to (1) better understanding of the situation at the outset, (2) more plan, (3) less tendency to "go off on a tangent," i.e., to respond impulsively to every opening, without considering or looking ahead. The adult has more control, the child more activity; the adult's control stands him in good stead at the outset, but the child's activity enables him to catch up shortly in so simple a problem as this little maze.

AVERAGE NUMBER OF ERRORS MADE, IN EACH TRIAL IN LEARNING A MAZE, BY RATS, CHILDREN AND ADULT MEN

(From Hicks and Carr)

Trial No.	*Rats*	*Children*	*Adults*
1	53	35	10
2	45	9	15
3	30	18	5
4	22	11	2
5	11	9	6
6	8	13	4
7	9	6	2
8	4	6	2
9	9	5	1
10	3	5	1
11	4	1	0
12	5	0	1
13	4	1	1
14	4	0	1
15	4	1	1
16	2	0	1
17	1	0	1

The table reads that, on the first trial in the maze, the rats averaged 53 errors, the children 35 errors, and the adults 10 errors, and so on. An "error" consisted in entering a blind alley or in turning back on the course. The subjects tested consisted of 23 rats, five children varying in age from 8 to 13 years, and four graduate students of psychology. The human maze was much larger than those used for the rats, but roughly about the same in complexity. Since rats are known to make little use of their eyes in learning a maze, the human subjects were blindfolded. The rats were rewarded by food, the others simply by the satisfaction of success.

TRIAL AND ERROR LEARNING IN ANIMALS AND MEN

The trial and error procedure in attacking a problem consists in doing something, which probably does not succeed, then doing something else, and so on till something does succeed. One way out is tried, then another and another, till a way is found which actually leads out. There is varied activity

till success occurs. Trial and error procedure is almost inevitable if the problem is entirely blind. But the question is whether anything is learned in such procedure, and this question can be studied by replacing the individual in the same problematic situation time after time, and noting any changes in his behavior.

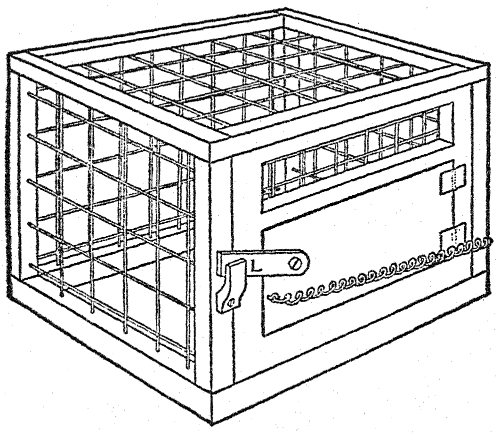


FIG. 14. — (From Watson.) A puzzle box. The animal must here reach his paw out between the bars and raise the latch, *L*. A spring then gently opens the door.

The puzzle-box experiment. Place a hungry young cat in a strange cage, with a bit of fish lying just outside, and you are sure to get action. The cat extends his paw between the slats but cannot reach the fish; he pushes his nose between the slats but cannot get through; he bites the slats, claws at anything small, shakes anything loose, and tries every part of the cage. Sooner or later he turns the button, gets out, and eats the fish. The experimenter, having noted the time occupied in this first trial, replaces the cat, still hungry, in the cage, and another bit of fish outside. Same business, but perhaps somewhat quicker escape. More trials, perhaps on a series of days, give gradually decreasing times of escape. The

useless reactions are gradually eliminated, till finally the cat, on being placed in the cage, goes instantly to the door, turns the button, goes out and starts to eat, requiring but a second or two for the whole complex reaction. Perhaps 15 or 20 trials have been required to reach this stage of prompt, unerring response. The course of improvement is rather irregular, with ups and downs, but with no sudden shift from the varied reaction of the first trial to the fixed reaction of the last. The learning process has been gradual.

There is no evidence that the cat reasons his way out of the cage. His behavior is impulsive, not deliberative. There is not even any evidence that the cat clearly observes how he gets out. If he made a clean-cut observation of the manner of escape, his time for escaping should thereupon take a sudden drop, instead of falling off gradually and irregularly from trial to trial, as it does fall off. Trial and error learning is learning by doing, and not by reasoning or observing. The cat learns to get out by getting out, not by seeing how to get out.[3]

So it would seem, at any rate, though we must remember that the cat is not blind, but is evidently responding to visual cues, to objects seen in and about the cage. The experiment seems to demonstrate the reality of learning by trial and error, which can be described as varied activity, repeated time after time, but with gradual elimination of the unsuccessful responses and gradual fixation of the successful response. Whether trial and error behavior is exactly favorable for learning or not, it at least provides a condition in which learning can and does occur.

Trial and error learning, though often spoken of as characteristically "animal," is common enough in human beings. Man learns by impulsively doing in some instances, by rational analysis in others. He would be at a decided disadvantage if he could not learn by trial and error, since often the thing he

[3] E. L. Thorndike, *Animal Intelligence*, 1911.

has to manage is very difficult of rational analysis. Much motor skill, as in driving a nail, is acquired by "doing the best you can," getting into trouble, varying your procedure, and gradually "getting the hang of the thing," without ever clearly seeing what are the conditions of success.

The puzzle experiment with human subjects. The puzzle boxes used in experiments on animal learning are too simple for human adults, but mechanical puzzles present problems of sufficient difficulty. The experimenter hands the subject a totally unfamiliar puzzle, and notes the time required by the subject to take it apart; and this is repeated in a series of trials till mastery is complete. In addition to taking the time, the experimenter observes the subject's way of reacting, and the subject endeavors at the end of each trial to record what he has himself observed of the course of events.

The human subject's behavior in his first trial with a puzzle is often quite of the trial and error sort. He manipulates impulsively; seeing a possible opening he responds to it, and meeting a check he backs off and tries something else. Often he tries the same line of attack time and time again, always failing; and his final success, in the first trial, is often accidental and mystifying to himself.

On the second trial, he may still be at a loss, and proceed as before; but usually he has noticed one or two facts that help him. He is most likely to have noticed *where* he was in the puzzle when his accidental success occurred; for it appears that *locations* are about the easiest facts to learn for men as well as animals. In the course of a few trials, also, the human subject notices that some lines of attack are useless, and therefore eliminates them. After a time he may "see into" the puzzle more or less clearly, though sometimes he gets a practical mastery of the handling of the puzzle, while still obliged to confess that he does not understand it at all.

Insight, when it does occur, is of great value. Insight into the general principle of the puzzle leads to a better general plan of attack, and insight into the detailed difficulties of manipulation leads to smoother and defter handling. The human "learning curve" (see Figure 15) often shows a pro-

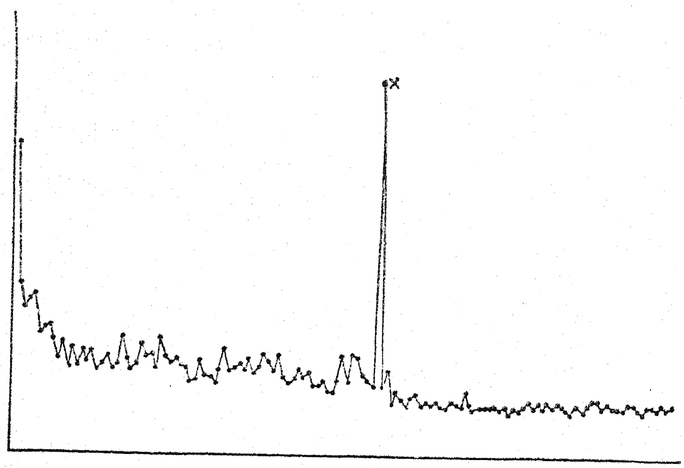


FIG. 15. — (From Ruger.) Curve for human learning of a mechanical puzzle. Distance above the base line represents the time occupied in each trial, the successive trials being arranged in order from left to right. A drop in the curve denotes a decrease in time, and thus an improvement. At X, the subject saw something about the puzzle that he had not noticed before and studied it out with some care, so increasing his time for this one trial, but bringing the time down thereafter to a new and steady level.

longed stretch of no improvement, followed by an abrupt change to quicker work; and the subject's introspections show that 75 per cent. or more of these sudden improvements followed immediately after some fresh insight into the puzzle.

The value of insight appears in another way when the subject, after mastering one puzzle, is handed another involving the same principle in a changed form. If he has seen the principle of the first puzzle, he is likely to carry over this knowledge to the second, and master this readily;

but if he has simply acquired motor skill with the first puzzle, without any insight into its principle, he may have as hard a time with the second as if he had never seen the first.

The mirror-drawing experiment with human subjects. The reality of trial and error learning in human beings is perhaps better demonstrated in this type of experiment than in the puzzle experiment. Anyone can try this experiment for himself, with very simple apparatus. Place a small mirror vertically on the table, with space in front of it to hold a sheet of paper. As you draw with pencil on the paper, watch your hand in the mirror. Arrange some sort of a screen between your eyes and your hand, so that you see your hand only in the mirror. Now provide some figure, such as a star, to be traced by the hand while watching the hand in the mirror. As the mirror disturbs the customary eye-hand coördination, there will be some difficulty in tracing the star. To make the experiment complete, you should have several stars, just alike, to be traced one after the other, and a watch to take the time of each trial. As objective data from the experiment, you will then have your successive tracings, with the time of each. An introspective report, made after each trial, of your experience during that trial, will also be of value. Spaced learning, it may be added, gives more rapid improvement in this performance than immediate repetition.

Though analysis of the effect of the mirror should, it would seem, enable the subject to master this performance almost at once, the well-established habits of eye-hand coördination are not so easily laid aside, and most subjects, as a matter of fact, find it necessary to resort to trial and error. At first, they are altogether baffled; then, by moving slowly and keeping close track of the results, they are able to check each false movement before it proceeds far, while the movements that are going somewhere near right they allow to take their

course; and so they manage to work their way around the star. Learning does occur under these conditions, for there is improvement from trial to trial.

What we notice in trial and error learning is (1) that the subject is strongly motivated towards a certain end-result, (2) that he is keenly alive, although (3) he is unable to see the solution, (4) that he engages in varied activity, some of

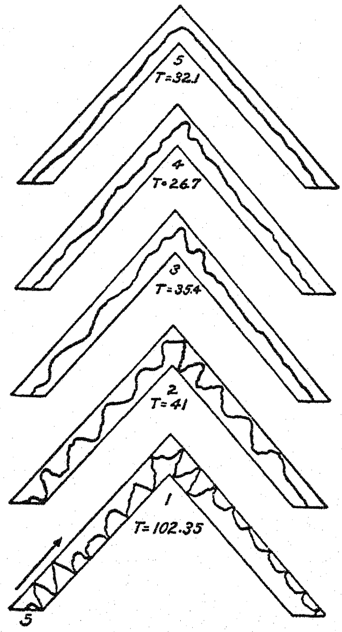


FIG. 16.— (From Snoddy, 1920.) The way a beginner negotiated a corner of the star on his first six trials in a mirror drawing experiment. The first trial is shown at the bottom, and the others in order upwards, the time occupied in each complete circuit being indicated by "T."

which is successful and some unsuccessful, and finally (5) that some selective process is at work, resulting in the elimination of the unsuccessful responses and the fixation of the successful, so that a fairly efficient performance comes out.

OBSERVATIONAL LEARNING IN ANIMALS AND CHILDREN

Learning by observation is typically human. The adult's superiority in tackling a maze may be summed up by saying that he observes more than the child — much more than the animal — and governs his behavior by his observations. The enormous human superiority in learning a simple puzzle, of the sort used in experiments on animals, arises from seeing at once the key to the situation.

"Learning by imitation." As it had been assumed that learning by imitation, which seems to be common in the human child, was a rudimentary form of learning within the power of many animals, the following experiment was designed to test the matter. The experimenter takes two cats, one having mastered a certain puzzle box, the other not, and places the untrained cat where it can watch the trained one do its trick. The trained cat performs repeatedly for the other's benefit, and is then taken away and the untrained cat put into the puzzle box. But he has derived no benefit from what has gone on before his eyes, and must learn by trial and error, the same as any other cat; he does not even learn any more quickly than he otherwise would have done.

The same negative results are obtained even with monkeys, but better success has been obtained with the anthropoid or man-like apes, the most intelligent of all animals below man. One ape having already learned to extract a banana from a long tube by pushing it out of the further end with a stick which the experimenter had kindly left close by, another ape was placed where he could watch the first one's performance and did watch it closely. Then the first animal was taken away and the second given a chance. He promptly took the stick and got the banana, without, however, imitating the action of the first animal exactly, but pulling the banana towards

him till he could reach it. This has been called learning by imitation, but might better be described as learning by observation.[4]

Such behavior, quite rare among animals, is common in human children, who are very observant of what older people do, and imitate them on the first opportunity, though often this comes after an interval.

Learning by "insight" in chimpanzees. A young chimpanzee was tested with a simple puzzle box, to be opened from outside by turning a button that prevented the door from opening. The device was so simple that you would expect the animal to see into it at once. A banana was put into the box and the door fastened with the button. The chimpanzee quickly found the door, and quickly found the button, which he proceeded to pull about with one hand while pulling the door with the other. Without much delay, he had the button turned and the door open. After about three trials, he had a practical mastery of the puzzle, showing thus considerable superiority over the cat, who would more likely have required twelve or fifteen trials to learn the trick. But now a second button was put on a few inches from the first, both being just alike and operating in the same way. The chimpanzee paid no attention to this second button, but turned the first one as before, and when the door failed to open, kept on turning the first button, opening it and closing it and always tugging at the door. After a time, he did shift to the second button, but as he had left the first one closed, his manipulation of the second was futile. It was a long, hard job for him to learn to operate both buttons correctly; and the experiment proved that he did not observe how the button kept the door from opening, but only that the button was the thing to work with in opening the door. At one time, indeed, in order to force him to deal with the second button, the first one was removed,

[4] M. E. Haggerty, *Psychological Bulletin*, 1910, vol. 7, p. 49.

but he still went to the place where it had been and fingered about there. What he had observed was chiefly the *place* to work at in order to open the door. We must grant that animals observe locations, but most of their learning is by doing and not by observing.

But this chimpanzee was rather young, and then, too, some chimpanzees are certainly much more intelligent than others. Besides, some things may be easier for them to see into than the door button used in the preceding experiment. Let us give the animal a fair chance, by placing the elements of the situation visibly before him, and not concealing them as in the puzzle-experiments.

A chimpanzee which had already learned to use a stick to poke a banana into his reach when it was lying on the floor outside his cage and beyond the reach of his unaided arm, was given two pieces of bamboo, one small enough to be inserted into the end of the other, and the banana was placed too far away to be reached with either stick alone. Could the animal learn, of himself, to make and use a jointed stick? For over an hour, the animal made various attempts to get the banana, making use of the sticks in various ways, but finally gave up and went to the back of his cage. A few minutes later, he picked up the two sticks again and played carelessly with them, and while doing so, by chance, as it seemed, got them end to end and pushed the smaller a short distance into the larger, when he jumped up, ran to the front of the cage, and started to pull in the banana with the jointed stick. When the loosely connected pieces fell apart, he put them together again, and got the banana in. Without stopping to eat, he pulled in everything else within reach. The next day, when the test was repeated, he began with a few useless movements, but in a few seconds put the sticks together and used them as before.

The evidence of "insight" consists in the suddenness of the transition from other behavior to the definite use of the jointed

stick, in the absence of any considerable amount of trial and error on the second trial, and in the animal's interest in the tool he had made. What he learned was a new combination of objects, rather than a new combination of his own movements. "Insight" need not mean more than that the animal definitely observed a certain combination of objects as being something of use.[5]

The "insight" experiment with young children. A very similar experiment has been tried on children of two to three years old. A nursery play-pen, with a fence as high as the child's chest, stood in the room, the child was placed in the pen, and some attractive toy was placed on the floor outside as the objective. The toy was too far away to be reached by the child's arm, but a stick was left inside the pen. After the child had learned (without any assistance) to fish with the stick, the stick itself, as well as the toy, was placed outside, but a shorter stick was left inside with which the long stick could be reached, while with the long stick the toy could be reached. When this had been learned, the experimenter proceeded to the jointed stick test, using two lengths of a jointed fish pole instead of the bamboo. Here follows the record of a little girl of 40 months in these tests.

Single stick, first day. She handled the stick and talked about it for a moment, and then dropped it, trying to climb out of the pen to get the toy; tried to reach the toy by leaning over the top of the pen, and by stretching for it between the bars; sought an exit, repeating over and over, "I can't get birdie"; asked the experimenter to move the toy closer; stepped on the stick, looked down on it, walked around, picked up the stick, banged with it on the wall, and threw it down; looked around and again tried to reach the toy as before and by pushing her legs out between the bars. As she now appeared tired, the trial was terminated.

Single stick, second day. The child reached for the toy through the spaces, first with right hand and then with left, shouting, "Today,

[5] W. Köhler, *The Mentality of Apes*, 1925, p. 132.

I can get him"; tried to climb out and again reached through the spaces. She stepped on the stick, pounced down upon it, and in ten seconds more had the toy; she repeated the performance for fun.

Two sticks. Child tried to reach the toy with the short stick and in 15 seconds threw it out of the pen. When the experimenter restored the stick, the child said, "Give me the other one, it's better." After a minute she threw the short stick out again and tried to climb out. The experimenter restored the short stick when the child was not looking. Child walked around and tried to reach the toy as before. But at the end of three minutes she reached for the long stick with the short one, and then for the toy with the long stick.

Jointed stick, first day. The child examined one of the sticks and tried to reach the toy with it over the top of the pen; examined the other stick and used it in the same way, repeating "I can't" over and over. Tried out a stick between the bars and over the top of the pen, finally striking it viciously against the floor; complained bitterly and tried again to reach as before, stretching and straining; tried to climb out and whined, "I can't." Trial terminated to avoid fatigue.

Jointed stick, second day. Child reached for toy as before and in 10 seconds said, "Look, I can't," but continued her efforts; placed sticks up against bars of pen, banged them together, etc. Tried to reach the toy with her hand through the spaces, to force her way out, to shake the pen, etc.; and finally gave up, saying, "Dolly does not want me to get him."

Jointed stick, third day. For three minutes, she behaved as before, complaining intermittently and finally giving up.

Jointed stick, fourth day. The child stretched for the toy over the top of the pen, striking out angrily with a stick, complaining and asking the experimenter to move the toy closer. After two minutes, she said, "Let's try big stick on little one," picked up the other stick, examined ends carefully and succeeded in fitting them, with a shout of "Bang!" In a few seconds she angled for the toy, reached it exultantly, and repeated the stunt several times.[6]

The interest here, as in the ape experiment, lies in the suddenness with which behavior of the trial and error sort was cut short by the observation of some useful fact. With these results in mind, one is inclined to go back to the typical trial

[6] A. Alpert, *Teachers College, Columbia University, Contributions to Education,* 1928, No. 323.

and error behavior, and query whether observations of a rudimentary kind may not have played an essential part in the attainment of success there too. But this query cannot be certainly answered at present.

Learning to follow a definite cue — the signal experiment. Some indication that animals do observe in a rudimentary way has come out of experiments which require the animal, in order to reach food, to take the right one of two doors before which he is placed. If the "right door" is the one on the right — or on the left — the animal learns the trick quickly; but if the right door is the one, sometimes on the right and sometimes on the left, over which a light is burning, or on which a white card is pinned, such an animal as the white rat learns the trick very slowly.

Place a white rat before two little doors,[7] both alike except that one has a white card on it. The rat begins to explore. If he enters the door with the card on it, he finds himself in a passage which leads to a box of food; if he enters the other door first, he gets into a blind alley, but continues his explorations and finally reaches the food. The first trial being thus completed, start the second trial by placing the rat back at the starting point, and he is likely to go straight to the door that just led him to the food, for he learns simple locations readily. But meanwhile the experimenter has shifted the card to the other door, connected the passage behind the marked door with the food box, and closed off the other passage, for the card in this experiment always marks the way to the food, and the unmarked door always opens into the blind alley. The sign is shifted irregularly from door to door, and the passages are changed to correspond. Whenever the rat gets into the blind alley, he comes out of it and goes to the other door, so finally getting his reward on every trial. But for a long time he seems incapable of guiding himself by the sign. How-

[7] R. M. Yerkes, *The Dancing Mouse*, 1907, p. 92.

ever, the experimenter is patient; he gives the rat twenty trials a day, and the right responses become more and more frequent, till after some thirty days every response is correct and unhesitating. The rat has learned to look for the marked door and go there, instead of responding only to position. Looking and seeing are essential here, and the rat's behavior thus includes a rudimentary form of practical observation.

The rat learns this trick more quickly if *punishment* for incorrect responses is added to the reward for correct responses. Place wires along the floor of the two passages, and switch an electric current into the blind alley, behind the door that does not, at the moment, have the card on it. When the rat gets the shock in the blind alley, he makes a prompt avoiding reaction, scampering back to the starting point and cowering there for some time; eventually he makes a fresh start, avoids the door that just led to the shock and enters the other door, though apparently without paying any attention, as yet, to the card, since on the next trial he avoids the *place* where he got the shock, even though the card has been shifted. But in a series of trials he learns to follow the sign.

This simple experiment teaches several things. It shows that places are learned very readily, and that the following of visible signs that shift from place to place is learned much more slowly. It shows that movements leading to reward are somehow selected, more or less gradually, as against movements that lead into blind alleys and so to delay in reaching the goal; and that movements that lead to "punishment" (injury or pain) are eliminated with extra quickness. Finally, it shows a rudiment of observation in learning by trial and error.

The delayed reaction experiment. This is a complication of the signal experiment, the question now being whether the animal will still obey the signal though it is made to disappear before he is allowed to go towards it. A convenient signal to

use here is an electric bulb burning above the door which at the moment leads to food. After the animal has thoroughly learned to go to the door where the light is burning, the experiment is modified by turning out the light, first while the animal is on the way, and later before the animal is free to start towards the lighted door. Now the animal is held while the light is burning, and only released a certain time after the light is out, and the question is whether, after this delay, he will still follow the signal and go straight to the right door. It is found that he will do so, provided the delay is not too long — how long depends on the animal. With rats the delay cannot exceed 5 seconds, with cats it can reach 18 seconds, with dogs 1 to 3 minutes, with children (in a similar test) it increased from 20 seconds at the age of fifteen months to 50 seconds at two and a half years, and to 20 minutes or more at the age of five years.

Rats and cats, in this experiment, need to keep their heads or bodies turned towards the designated box during the interval between the signal and the release; or else lose their orientation. Some dogs, however, and children generally, can shift their position and still, through some inner orientation, react correctly when released. Seeing the signal produces some internal response in the animal, even when the full response of going towards the signal is delayed. This internal response, however rigidly we apply Lloyd Morgan's canon, amounts certainly to an observation of the signal as showing the way to be taken.[8]

A slightly different test for delayed reaction has been tried on monkeys, with interesting results. Instead of using an artificial signal which the animal had to learn in advance of the main test, the experimenter simply placed two inverted tin cups on the floor in front of the monkey, and let the monkey see him place a piece of banana or lettuce under one of the cups. Then both cups were concealed by a large screen. The

[8] W. S. Hunter, *Behavior Monographs*, 1913, vol. 2, pp. 1–86.

monkey, already trained to sit in a chair till told to "come get the food," watched these proceedings, and after a certain delay was told to get the food, the question being whether he would still go promptly and surely to the cup containing the food. With only occasional errors, the monkey responded correctly after delays lasting up to several hours, even though he moved about during the interval, and was taken out of the room during the longer delays.

In some experiments, the experimenter secretly substituted a piece of lettuce for the piece of banana that the monkey had seen placed under the cup, and when the monkey, after the delay, went to this cup, raised it, and started to take what was underneath, he checked himself, looked all around, and went away without taking the lettuce, though he would usually eat lettuce, preferring banana however. We see then that the monkey, by seeing where food is placed, gets some kind of inner adjustment both to the location of the food and to the kind of food that is there. We also see that the monkey can retain this adjustment during a period of hours spent in a variety of other activities.[9]

All these varieties of the signal experiment show that we have to reckon on a certain amount of rudimentary observation in animal learning. There is some singling out of landmarks, and some following of such indications even after a delay. Trial and error learning, accordingly, is not a mere blind running hither and thither and pawing this way and that, but rather a responding to objects as being in definite locations, at least, and sometimes to objects as having more or less definite characteristics.

THE CONDITIONED REFLEX

No work on animal learning has awakened so much interest among psychologists as that of the Russian physiologist Pavlov,

[9] O. L. Tinklepaugh, *Journal of Comparative Psychology*, 1928, vol. 8, pp. 197–236.

because his work has seemed to reveal learning at or near its bottom level, and to lay bare the fundamental process in all learning.

About the year 1900, Pavlov, while actively at work on the physiology of digestion, using dogs as subjects, introduced a minor operation, by which the saliva from one of the glands in the dog's mouth was carried out through the cheek by a little tube, so that it could be easily observed and measured. He then noticed that the saliva flowed rapidly, not only when food was actually in the mouth, but when the dog saw food before him, or when he saw the dish in which the food was usually given him, or when he saw the person approach who usually brought him his food, or even when he heard the footsteps of that person in the next room. Now when the stimulus of food is actually in the mouth, the salivary response is a natural and permanent reflex, but the same response aroused by accessory stimuli, such as the sight of the food or of the dish or the sound of the feeder approaching, depended on the animal's past experience, and was thus artificial or subject to certain conditions. Pavlov therefore called it a conditioned reflex, and the name has stuck, though it is rather blind, and unfortunate in that it introduces a new use of the word "condition," already a hard-worked term in all kinds of scientific talk, including psychology.

The establishment of a conditioned reflex. Pavlov wished to discover how these artificial reflexes got started, and so attempted to establish a conditioned salivary response to the ringing of a bell, the flashing of a light, or the brushing of the animal's skin. He soon found the way to establish any such conditioned response. His procedure was as follows.

A hungry dog — a well-treated animal, quite at home in the laboratory — was placed standing on a table, and loosely secured by slings about the shoulders and hips, suspended from above, so that he could move only a step or two. When the

animal was quiet, an electric bell began to ring, and after it had rung for a certain time (often for a minute, but a few seconds were sufficient), some food was placed in the dog's mouth and his saliva began to flow. After a pause of a few minutes, the bell started up again, and, as before, food was given after the bell had been ringing for a certain time. When this sequence of bell . . . food, bell . . . food had been repeated a number of times, the dog however still remaining hungry, the saliva was observed to flow before the food was supplied. The bell now caused the dog to look and turn towards the source of food, and at the same time his salivary glands became active. There was a complex motor and glandular feeding activity, initiated by the sound of the bell. Pavlov's attention was directed mostly to the glandular part of this total response, because it could be measured by measuring the flow of saliva. At the outset of the experiment, the bell did not excite any flow of saliva, but as the bell — food combination was repeated time after time, the bell began to give a small flow and then a progressively larger amount. Thus the conditioned reflex was established, at least for the moment.

Next day the same procedure was repeated. No saliva at the first sounding of the bell, but the bell — food combination needed only to be repeated a few times before the conditioned reflex was reëstablished. There was some retention, then, as tested by our old "saving method" used in human memory experiments. After a few days of this same procedure, the conditioned response (both motor and salivary) held over from one day to the next, without needing reëstablishment each day.

Extinction or wearing out of a conditioned reflex. Though the conditioned response can be well established by the procedure just described, we are not to suppose that it has anything like the fixity of the natural reflex. It can be trained out in much the same way as it was trained in. Simply apply the

conditioned stimulus (i.e., the artificial stimulus which has come to give the salivary response) time after time without following it by the natural stimulus. Here, for example, is the record of one of Pavlov's experiments, in which the conditioned stimulus was the beating of a metronome. The salivary response to this stimulus had been well established. Now on a certain day the metronome was sounded for 30 seconds, without any food, and there was a large flow of saliva. Three minutes later, the same procedure was repeated, with a smaller resulting flow of saliva; and so on, till the flow of saliva was no longer excited by the metronome alone. The gradual decrease and final extinction of the salivary response can be seen in the following table of results:

Time when each 30-second stimulation by the metronome began	*Quantity of saliva produced, in drops*
12.07 p.m.	13
12.10 "	7
12.13 "	5
12.16 "	6
12.19 "	3
12.22 "	2.5
12.25 "	0
12.28 "	0

This extinction, however, is only temporary, for if the dog is now taken away, and brought back the next day, the metronome again gives the salivary response. But if the food is omitted this day also, the extinction is more rapid than on the first day; and repetition of the extinguishing procedure, day after day, finally causes the conditioned response to disappear permanently. After one day's extinction of the conditioned response, it can be readily reëstablished by applying the food along with the metronome, but when the extinction has been

very thorough, by repetition on several days, the conditioned response is very difficult to reëstablish.

Narrowing of the range of stimuli that arouse a certain conditioned response. A new conditioned response, that is working well at the moment, but has not yet been thoroughly trained in, will be aroused by other stimuli more or less similar to that used as the conditioned stimulus. For example, if a certain bell has been used, and the salivary response has been tied to this bell, it will be aroused also by almost any other bell or similar sound. But when the same bell has been used day after day throughout the complete establishment of the conditioned response, other bells are likely to be ineffective.

The range of effective stimuli can be narrowed more rapidly if when these other sounds are given, the natural stimulus is not applied, while it is always applied when the particular bell is sounded. This procedure establishes two conditioned responses: that of flow of saliva to the particular bell, and that of non-flow of saliva to the other sounds used.

Another similar effect may be called the delayed conditioned response. Let the bell start ringing always one minute before the food is placed in the mouth. In the early stages of such an experiment, the saliva starts to flow almost as soon as the bell starts ringing; but as the experiment progresses, day after day, the food always coming after the bell has been ringing for one minute, the conditioned flow of saliva begins later and later in this minute, till it finally is delayed till about the time when the food is due.

Effect of distracting stimuli. A "distracting" stimulus is simply any fairly strong stimulus which breaks in and disturbs the conditioned response, as it also disturbs any of the negative effects we have just been describing. When a conditioned reflex is young, it can be prevented by a distracting stimulus applied along with the regular conditioned stimulus. When a previously well-established conditioned response is just barely

extinguished, it reappears promptly whenever a distracting stimulus is applied along with the conditioned stimulus. When a conditioned response has been established to a bell, with non-response to other similar sounds also established, the distracting stimulus will cause the salivary response to be made to the other sounds, as if a habit of non-response were disturbed. And when the delayed conditioned response has been established, a distracting stimulus coming in during the delay causes the saliva to flow at once, as if the distracting stimulus disturbed the holding back of the salivary response. All these facts are interpreted by Pavlov as indicating that the non-response is more than a mere passive absence of response. He thinks of it as an active inhibition of salivary secretion. The distracting stimulus disturbs the inhibition just as it disturbs the positive conditioned response.

Conditions favorable to the establishment of a conditioned reflex. The result accomplished in these experiments is the linking of salivary activity to a stimulus which has no special preëxisting connection with such activity, and the way to accomplish this linkage is to have the artificial stimulus present just when the salivary activity is about to start. You start up the activity by applying any stimulus that you know will arouse it. You may use for this purpose the natural stimulus, or you may use some artificial stimulus that has previously been attached to this activity. It makes no difference how you get the activity started; the only thing is to get it started at the right time. You must start up the activity after the artificial stimulus has started, not before.

If the salivary machine, consisting of the gland and its nerves and nerve centers, is in a torpid condition and cannot be aroused to activity, then, of course, the conditioned reflex cannot be established. The animal, then, must be awake. Dogs often go to sleep in a protracted experiment, and so spoil the

experiment. The animal must be hungry; a full stomach inhibits the salivary activity.

The artificial stimulus which you are trying to attach to the salivary activity must be fairly strong or at least impressive to the animal. In general, the stronger the artificial stimulus, the more quickly is the conditioned response established. But if the stimulus is so strong that it irritates the animal and arouses a defence response, then it does not become attached to the salivary response. You must see to it that no other response gets in ahead of the salivary response which you are trying to tie up to the artificial stimulus. The sequence, artificial stimulus — salivary response, must be kept as clean and regular as possible.

Since the conditioned response cannot usually be established in a single trial, repetition is an essential condition of success, and spaced repetition is even more important here than we found it in memorizing.

Distracting stimuli must be avoided. So important did Pavlov find this requirement that he had a special laboratory building constructed for conditioned reflex work, with elaborate provision for excluding all extraneous lights and sounds, and even for keeping the experimenter out of the dog's sight.

Though Pavlov speaks of the conditioned response as a "reflex," he means only that it has the general form of a reflex and is based on a reflex, not that it is a response at the "reflex level," and carried on wholly by the lower nerve centers, without participation of the brain. He found by experiment that no conditioned reflexes could be established in a dog whose cerebral hemispheres were removed. One prime condition of success in establishing a conditioned reflex is that the animal's brain must be in good working order. Pavlov believes, in fact, that half of the value of the cerebrum to an animal or man consists in giving conditioned responses; the

other half consists in analyzing the mass of stimuli that come in from the world by way of the sense organs. The whole activity of the cerebrum would then consist in singling out particular stimuli and attaching them to motor and glandular responses. Most stimuli that reach the animal by way of the eye and the ear are of no vital significance in the animal's life, except as they come to serve as signals of food or danger or mates, etc.; and they become signals by the conditioning process, as described. Such is Pavlov's theory of the whole of learning, but it will be seen that he leaves out of account the organizing of movements into complex action patterns, which, also, belongs to the cerebrum.[10]

Conditioned fear responses. Pavlov generalizes from work in a narrow field, having concerned himself almost entirely with the salivary response in dogs. However, it has been found that salivary and other conditioned responses can be established in man. The human being, having more going on in him than a dog, is liable to all sorts of distracting influences, and cannot be expected to give clean-cut results, especially in an experiment in conditioning motor responses, which are so subject to deliberate control. But there is one class of responses that has been shown to be conditionable, both in animals and in children, and the facts of this matter should be known before any generalized theory of learning is attempted. Fear, as a response to merely threatened injury, is perhaps always a conditioned response.

Some form of avoiding response is naturally aroused by any stimulus that actually hurts the animal or man, and these avoiding responses are readily conditioned and then appear as fear responses. A rat that gets an electric shock in a certain passage or blind alley makes a prompt avoiding response, and thereafter avoids that place. An avoiding reaction to a place

[10] I. P. Pavlov, *Conditioned Reflexes*, 1927, and *Lectures on Conditioned Reflexes*, 1928.

can be established in one or two trials, and is not readily extinguished.

How conditioned fears may arise in the little child is illustrated by an important experiment of Watson and Raynor. The object of the experiment was to see whether the avoiding response could be attached to the sight of a rabbit, which was known not to be a natural stimulus for this response. The avoiding response was directly aroused by a loud rasping noise close to the child's ear. The child was slightly under a year old. When the rabbit was held out to the child, the child showed no fear, but reached out his hand to take the rabbit. At this instant the loud rasping noise was sounded, and the child quickly withdrew his hand with other signs of fear. When this procedure had been repeated a number of times, on two days, the rabbit alone, without the noise, gave the fear response. The avoiding response here takes the place of the salivary response in Pavlov's experiment, and the rabbit takes the place of the bell; and as the bell was sounded just before the salivary response was aroused, so here the rabbit was presented just before the avoiding response was aroused. So far, the experiments are exactly parallel, and give parallel results.[11]

There are differences, however. The conditioned fear experiment does not succeed with all babies. Some children turn around and scowl at the harsh noise, but then return to the rabbit. Possibly these children are less sensitive to noise (and certainly it takes a whole lot of noise to frighten some children), but their behavior looks rather as if they kept the noise and the rabbit separate, responding to the one and then to the other, as if they saw that the noise didn't come from the rabbit and had nothing to do with the rabbit. Thus intelligent observation may protect a child from a multitude of

[11] Watson and Raynor, *Journal of Experimental Psychology*, 1920, vol. 3, pp. 1–14.

senseless fears. But there can be no doubt that many fears and dislikes originate in the manner demonstrated in the experiment.

But there is another significant difference between the conditioned fear and the conditioned salivary response. The latter was readily extinguished by repeating the artificial stimulus a number of times without reinforcement by the natural stimulus. If that had been true of the conditioned fear, then presentation of the rabbit a number of times without the rasping noise would have extinguished the fear response, and the child would have returned to his original positive response to the rabbit. But, as a matter of fact, once a child has acquired a fear of the rabbit, the oftener the rabbit is presented the more the child becomes disturbed. It is a long, difficult job to rid a child of a conditioned fear, once well established.

This last result is really what we should expect from most of the facts of learning. The oftener a given cue or stimulus has aroused a certain response, the more likely it is to do so again, and the absence of the stimulus that originally gave the response was found, under the head of "recitation" in memorizing, to be a very favorable condition for establishing the response. The real wonder is that it does not work so in the case of the conditioned salivary response.

The difference between the two cases may lie in the fact that the conditioned salivary response is always followed at once by a check-up, which is lacking in the conditioned avoiding response. The conditioned salivary response was established as a preliminary to actual food in the mouth, and was checked up at once, on every trial, by the presence or absence of food. If the food came, the response to the preliminary bell was strengthened, but if the food did not come, the conditioned response was weakened. But an avoiding response does not furnish a check-up. When the rat avoids the place where he

has received a shock, he doesn't get any shock, whether there is any shock there or not. When the child shrinks from the rabbit, he doesn't find out whether the rabbit hurts or not. It appears, then, that the check-up by results is an important factor even in that simple type of learning which we call the conditioned response.

OTHER SIMPLE FORMS OF LEARNING

The conditioned reflex is perhaps not so simple as it first seems, and at any rate there are other types of learning that are fully as simple.

Negative adaptation. Apply a harmless and unimportant stimulus time after time in quick succession; at first the animal makes some avoiding or exploring response, but with the continued repetition of the stimulus he ceases to respond, and is said to have become negatively adapted to it. The response has been detached from this particular stimulus.

Even in unicellular animals, negative adaptation occurs, but in them it is only temporary, since the original response reappears when the stimulus is given again after an interval. But in somewhat higher animals, permanent adaptation is common, as illustrated by a famous experiment on a spider. While the spider was on its web, a tuning fork was sounded, and the spider made its regular defensive reaction by dropping to the ground. It climbed back to its web, the fork sounded again, the spider dropped again; but after several repetitions in quick succession, the spider ceased to drop. Next day, to be sure, it responded as at first; but after several days of this, it ceased permanently to respond to the tuning fork.

Negative adaptation is much like the extinction of a conditioned reflex, except that the response that is extinguished in negative adaptation may be a natural and not a conditioned response, and except that we have to find the "check-up"

that does the extinguishing in negative adaptation. In the spider's case, the extinguishing factor was probably the useless labor of climbing back to its web.

Negative adaptation is common in domestic animals, as well as in men. The horse "gets used" to the harness, and the dog to the presence of a cat in the house. Without negative adaptation, the adult would be compelled to attend to everything that aroused the child's curiosity, to shrink from everything that frightened the child, to laugh at everything that amused the child. Negative adaptation eliminates responses that are not worth the trouble.

Regularizing of a variable response. A very elementary form of learning must not be overlooked. It is illustrated by another famous experiment, this time upon newly hatched chicks. If grains are strewn before a chick one day old, it pecks at them, seizes them in its bill, and swallows them; but, its aim being poor, it actually gets only a fifth of what it pecks at; next day, however, it gets a half, in another day or so three quarters, and after about ten days it reaches its approximate limit of 85 per cent. Here no new response is learned, nor is the native response attached to any new stimulus, but the check-up of success and failure gradually steadies the response.

Strengthening of an originally weak response. Here we have learning — if it can be called learning — of the very simplest type. The new-born baby certainly does not learn to breathe; he hasn't the time. Nor does he learn to cry, for he manages that as soon as he has the air in his lungs to cry with. But his breathing and crying, weak at first, are strengthened by exercising his lungs and muscles and the nerve centers that take part in these activities. The strengthening of an activity by its own exercise is a fundamental fact in learning, a fact which has shown itself time and again in the more complex forms of learning that have been passed in review.

GENERAL REVIEW OF THE FACTS OF LEARNING

If the many-course dinner of experiments on learning that has been served seems almost too generous, the host may at least present this excuse, that there is plenty in the larder that has not been touched. But the time has certainly come for a little after-dinner speaking. We have had three main questions in the back of our minds all through this long survey of varieties of learning. We have been asking what is learned, and under what conditions it is learned, and what can be the fundamental processes that occur under these conditions and that give us the achievements of learning.

Generalized statement of the results of learning. Learning amounts to a change or modification of behavior. The immediate result of learning, no doubt, is modified structure, especially brain structure, which is retained, subject to the law of atrophy through disuse, until called into action again, when it gives the modified behavior. But since the structural changes in the brain, though effective, are minute and hard to observe, it is the changes in behavior that must guide us towards a theory of learning. Our first approach towards such a theory, then, is to ask in what respects behavior is modified by learning, or in what ways activity after learning differs from the activity before learning.

One obvious modification is the *strengthening* of an activity, and another, closely allied, is the greater speed of the activity after learning and practice.

The higher units or action patterns that have been noted from time to time show that learning modifies activity by building up an organized *combination* of simpler acts.

The reverse result, *isolation* of a part of an original complex activity, so that the part can be executed separately, is a fact that has not been brought out, but a fact of importance, nevertheless, in motor skill. The fingers naturally move together,

but we learn to move them separately, as in piano playing or using the typewriter. A less important but instructive fact of the same kind is that the ear, which most of us cannot move except by making a contortion of the whole face and scalp, can be brought under control by practice; each ear can even be taught to wiggle alone. And there are many similar instances.

The regularizing of a variable act was seen in a small way in the chick's pecking, and in a larger way in all trial and error learning. The learned performance is a *selection* from the varied activity that occurs before and during learning.

Simplification or reduction or *economy* of activity was seen under the head of "short-circuiting" in memory work, and appears also in motor skill. Superfluous muscular exertion, which is evident in attempting to perform an unfamiliar act, disappears gradually with practice. One who first tries his hand on the dynamometer for measuring strength of grip, works with both hands, with his neck and jaw, and even with his legs; but after practice with this instrument, the effort is limited mostly to the hand that does the real work. One learns to economize energy. This result of learning seems contrary to the strengthening first mentioned, but the fact is that the strength of a movement is increased by practice, when the performance demands additional strength, and diminished by practice, when the original effort was greater than necessary.

These are changes in the response, without regard to the stimulus that arouses it. The changes still to be noted are changes in the connection between stimulus and response.

The *detachment* of a response from a stimulus is seen in negative adaptation, and in the extinction of a conditioned reflex. The response of approaching a particular place (as a blind alley) is very quickly detached from that place if an electric shock is received there, and gives way to the avoiding

response. In all trial and error learning, the unsuccessful responses are eliminated, or detached from the situation.

The *attachment* of a response to a stimulus that did not originally have the power to arouse it is seen most clearly, perhaps, in the conditioned reflex experiment, but clearly enough also in the signal experiment, and indeed throughout the whole field of learning.

The *reduction of the stimulus* that arouses a response, which was so prominent a fact in our memory studies, can be regarded as a special case of the attachment of the response to a new stimulus, here a reduced stimulus. But it is equally possible to turn about and regard all cases where a response gets attached to a new stimulus as belonging under the head of reduced cues. For example, in Pavlov's experiment, the flow of saliva was first aroused by a total situation including the bell and the food in the mouth, but later the same response occurred when the situation was reduced by leaving out the food. This is a perfectly good statement of the facts of the matter.

One general, inclusive, and most important result of learning is the better *adaptation* of the response to the situation. In a broad way, this modification sums up all the others. But if we ask in what the better adaptation consists, we are driven back to the more specific changes already listed. However, it is well to let this fact of better adaptation stand in our list of the results of learning, to remind us that it is somewhat artificial to think of the individual apart from his environment. The environment belongs in the picture, not only as giving the stimuli that arouse a response but also as checking up on the response after it is made. In seeking to explain how the combination and isolation of responses and their new connections with stimuli are brought about in the process of learning, we must not forget that the environment is always there, checking up on the individual's behavior.

Under what conditions learning occurs. Conditions favorable or unfavorable to learning may exist in the situation that confronts the individual, or in the individual himself.

For example, if you desire your subject to learn a person's name, you arrange the external situation so that the person and the name are there together. You speak the name while the person is before the subject, or at least while the subject has the person in mind. To employ a time-honored word in the psychology of learning, you present the two in *contiguity*. Contiguity is a favorable external condition for forming an association between any two things; indeed, it is more than merely a favorable condition — it is a necessary condition. Unless the two objects are brought together in the subject's experience, he does not connect them one with another. If we think of learning as the formation of associations or connections, then the old law of association by contiguity states a necessary condition for all learning.

But this external condition, though necessary, is not sufficient to insure learning. Our subject may not connect the name with the person, even though both are presented together. In a "paired associates" experiment, though he connects the words of each pair with each other, he does not connect the contiguous pairs, so as to recite the list of pairs in order — unless he has set out to do so. The contiguity of the bell and the food, in the conditioned reflex experiment, does not attach the flow of saliva to the bell unless the dog is hungry so that the food stimulus actually arouses saliva. The stimuli must not simply be presented together, but they must be responded to together. Connections are established by the activity of the responding individual, and not by the contiguity of the stimuli.

So the most important conditions of learning are conditions present in the learner. Not only his general condition —

whether asleep, drowsy, or wide-awake, whether feverish, intoxicated, or normal, whether attentive or inattentive to the task to be learned — but also the way he responds to the situation, are important in determining what learning shall take place. The external conditions, such as contiguity, such as repetition and spaced repetition, and such even as the check-up by the environment on the outcome of the subject's performance, are important because of their influence on the activity of the subject.

The general types of activity in which learning occurs seem to be three in number. Learning occurs during trial and error activity, during observant activity, and during the sort of activity, wherever it should be named, that gives the conditioned reflex.

The characteristics of trial and error behavior are that it is aimed at some goal, that it is relatively blind and unobservant, and that it is varied. The variation of activity results from check-up by the environment. If the first response to the situation reached the goal, there would be no other response on that trial at least. But when the first response results in a check, some other response takes its place. The strange fact is that out of this medley of actions, in the course of repeated trials, the unsuccessful responses gradually disappear, while the successful remain and are organized into a definite action pattern, such as is seen specially well in maze running. Evidently the check-up by the environment does more than arouse the varied activity; it is responsible also, in some obscure way, for the selection of some responses as against others. But whether trial and error behavior is really as blind as it seems, we saw reason to doubt. Almost certainly there is a small amount of observation present, a noticing of places to go to and of places to avoid, if nothing more. The delayed reaction experiment shows that definite adjustment to locations certainly takes place in animal learning.

That observant activity, when it does occur, is the most favorable of all conditions for learning is open to no doubt whatever. When the location of food is definitely noticed, the learning may be practically instantaneous, so far as going to that place is concerned. When the way to joint two sticks together is definitely observed, trial and error behavior is cut short. In the higher types of learning, and perhaps in the lower as well, the facts observed consist largely of patterns and relationships present in the situation, and the observation of them enables the man or animal to adapt his behavior to a complex environment.

To come now to the conditioned reflex experiment, what sort of activity of the animal occurs here? At first sight, it appears to be no activity at all, but simple passivity. The dog stands there, and receives two stimuli in succession, the bell and the food. However, the food stimulus arouses feeding activity, of that there can be no doubt, so that the really important sequence of events is bell followed by feeding activity (including the flow of saliva). Now the bell, though it may arouse no more elaborate response, at first, than pricking up of the ears, certainly does start something in the dog's brain. It starts up a sensory activity, a hearing and listening activity. The sequence of events in the animal, then, is a certain sensory activity followed by feeding activity. Out of this sequence of activities, repeated a number of times, emerges the conditioned reflex, which amounts to an attachment of the feeding activity to the specified sensory activity.

In speaking of a "sensory activity" of the animal, we need not worry about being anthropomorphic, for we need not assume that the dog "hears" and "listens" in the conscious human way. All we need assume is that the noise striking the ears sets up a special brain activity, which differs according to what the noise is, and is different for a noise and for a light, etc.

A FORMULA FOR THE ELEMENTARY PROCESS IN LEARNING

After thus summarizing the results of learning, and the conditions under which it occurs, we have reached the point where we should try to tell what it is, essentially. To answer this question properly, we should turn to physiology and discover what happens in the brain. But since we have agreed to defer such physiological considerations till a later chapter, all we can do here is to formulate the elementary fact of learning in terms of a linkage or connection established between two activities — such a connection that the first activity is able to arouse the second. Let us proceed as follows: first we will seek a formula for the conditioned response, then we will generalize this formula in the hope of making it cover the more complex forms of learning, and after that we will review the complex forms briefly, in order to see whether our formula fairly covers them.

A formula for the conditioned reflex. In the establishment of a conditioned reflex, the essential facts are that (1) a sensory activity has been set up by the conditioned stimulus, and this sensory activity has no very definite or adequate motor response; it hangs fire, or does not discharge promptly into movement; (2) at this moment, in response to another stimulus, an important motor activity, such as feeding or avoiding, starts up and dominates the individual; (3) the undischarged sensory activity gets drawn into this dominant motor activity, and a linkage thus takes place between the sensory and the motor activity, which linkage is further strengthened by repetition of the occurrence.

When a conditioned reflex is being *extinguished*, what happens is just the same, except that the dominating activity is now a checking or inhibiting of some performance. The bell-hearing activity begins to discharge into feeding, but, food being withheld, feeding is checked and the inhibition of feeding becomes the dominant activity of the animal for the moment,

so that bell-hearing discharges into feeding-inhibition, and becomes linked with that as its conditioned response.

Our formula for the conditioned reflex is, then, that the dominant motor activity of a given moment absorbs the undischarged sensory activity that may be present, and so establishes a connection from that sensory to that motor activity; which connection is strengthened by repeated use.

A generalized formula. Since the linkages that we find in more complex forms of learning are not always clearly sensorimotor, what we need to do to make our formula fit them is to drop the words "sensory" and "motor," and say simply that the dominant activity of any moment tends to absorb any other present activity that is hanging fire or undischarged, and thus to establish a connection from that other activity to the dominant activity; which connection is strengthened by repeated use.

HOW THE FORMULA APPLIES TO VARIOUS TYPES OF LEARNING

In most instances of learning, the learner does more than he seems to do in the conditioned reflex experiment. Instead of simply waiting for things to happen to him, he goes out and makes them happen, as in trial and error learning. His internal activity is more complex: on the sensory side, he observes patterns and relationships, and on the motor side he responds with complex action patterns. But for all the complication, the learning process may consist of the same elementary processes of new attachments, of positive and inhibitory activity, and of growth through exercise, and the necessary environmental conditions of learning may still reduce to contiguity and check-up. Let us examine a few typical cases, with our theory in mind.

Reduced cues. The response here was originally aroused by a complex of stimuli, as in the case of the baby smiling when some one amused him. Later, the response was aroused by

the mere sight of the person. Originally, then, the sensory activity of seeing the person discharged into the main motor activity of the moment, the smiling or laughing activity, and thus a connection was established between the sight of the person and this motor activity. The inner process in reduced-cue learning seems to be the same as that in the conditioned reflex, except for the fact that the response that becomes attached to a stimulus was originally aroused by a combination of stimuli, instead of by a single stimulus like food in the mouth; and the stimulus to which the response becomes attached was originally one of the combination of stimuli that aroused the same response. Since reduced cue is so widespread throughout the field of learning, it may be worth while to restate our general law of learning in this modified form: when a response is aroused by a combination of stimuli, the connection of each of these stimuli with the response is used and strengthened.

Observant learning. By means of observation, the learner helps along the process of learning. If he simply singles out and dwells on a certain stimulus, he thereby strengthens the sensory activity aroused by this stimulus, and so increases the discharge of energy from the sensory into the motor activity. Probably even Pavlov's dogs did as much observation as this. But observation may help along still more if an object is observed to be related to the main activity, as when the monkey noticed his food being placed under a certain cup, or as when the child saw the stick as a means of reaching for a toy. Somehow, observing the way to the goal, or the means to an end, operates very effectively to attach the main activity of the moment to the observed objects. How observation operates can perhaps be gathered from the case of learning the name of a person who is being presented. If you wish to be able later to speak this person's name just from seeing him, you help along the learning process by looking at the person and

repeating the name to yourself. What you are doing, in terms of our theory, is to make sure that the sensory activity of seeing the person discharges into the motor activity of saying his name. There may be other persons in sight, and other names may be heard — distracting stimuli these, and likely to disturb the particular connection you wish to establish. But by looking at the person and repeating his name, you time the sensory and the motor activities just right to make the one discharge into the other. Thus by an observation, which might be expressed in the words, "This man's name is X," you decidedly help along the learning process. Probably all forms of observant and intellectual learning consist in so managing matters — both the environmental situation and the subject's own activity — as to afford favorable conditions for the elementary processes that we saw in the conditioned reflex.

The learning of action patterns. The combination of movements into higher units or action patterns was seen to be very important in skilled work, such as telegraphy and typewriting, and traces of such motor combination were seen even in the rat's maze running. Probably the combination of smaller responses into organized total actions enters into almost all learning. In accord with our general theory that regards the elementary learning process as consisting in the attachment of a response to a new stimulus, we should expect two or more movements to be combined by attaching them to the same stimulus.

Some action patterns are combinations of *simultaneous* movements, like the coördinated use of both hands in using an ax, or in shooting with bow and arrow. We may examine a case from automobile driving, the combination of foot movements upon the brake and clutch pedals. The beginner is apt to forget to use the clutch along with the brake, because there is nothing that reminds him of the clutch, though the need of stopping the car is a clear cue for applying the brake. When

he wants to stop the car, then, he presses his right foot on the brake, but neglects to press on the clutch with his left foot. Result, engine stalled, driver chagrined. He needs a cue to start the clutch movement at the right time, and says to himself, "Clutch, clutch, remember clutch!" The next time he wants to stop the car, he may think "clutch" at the right moment, just after getting the cue for applying the brake, and so move both feet together. So he enables the brake cue to discharge partly into the clutch movement, and thus both brake and clutch movements become attached to the same cue, and are combined into an action pattern.

The combination of *successive* movements into an organized sequence is illustrated by the word-habits in typewriting. The expert responds to the word "and" in his copy by a little pattern of finger movements; but the beginner has to spell out the word and make a separate response to each letter. Some day, when his letter-habits are well mastered and he is trying for more speed, he begins to anticipate and prepare for the second and third letters of the word while actually writing the first, and thus the word stimulus discharges into all three finger movements, and these become bound together by being attached to the word stimulus. The separate letter stimuli can then drop out; spelling is no longer necessary. Each finger movement also becomes attached to the feeling of the preceding finger movement, and so the total action pattern is all the more closely knit together.

Trial and error learning is on the whole the most difficult of all forms to explain in terms of our theory — or in terms of any other theory that has been suggested. The difficult thing to explain is the selection of the successful response as against the unsuccessful. Since both the successful and the unsuccessful are much exercised during the trial and error behavior — and often the unsuccessful more than the successful — one might expect both to be learned side by side and to persist alike

no matter how long the trials were continued; instead of which, the environmental check-up of success and failure gradually eliminates the false responses and strengthens only the correct sequence of movements. Out of the irregular varied behavior a definite action pattern takes shape. The environmental check-up is the external factor that gives this result; but the question is as to what can be the internal process of selection.

Probably we must admit a certain amount of observation of locations and landmarks in all trial and error learning, and observation would help establish the needed connections, in the way already described. Inhibition, so clearly present in the conditioned reflex, doubtless operates also in trial and error learning. It probably operates in two ways.

First, let us see how inhibition may operate in a detail of the trial and error learning. A rat, going through a maze in search of the food box, comes to the junction of two lanes, and responds to this situation by entering the right-hand lane, which turns out to be a blind alley so that he soon comes back to the junction and takes the other lane which leads him to the food. Now the question is whether, the next time the rat comes to this junction, he will be more likely to enter the blind alley or to take the other lane. The first time, he responded positively to the blind alley, by entering it, and again negatively, by giving up and turning away from it. He has two opposed conditioned responses to the situation of being at the entrance of that alley, and so the effect of the first trial will be to leave him rather neutral toward the blind alley. But the lane leading to the food he responded to only in the positive way, because he was never forced back out of it. Thus the balance of conditioned responses gives the correct path an advantage. In a word, the false moves are subject to inhibition, and so gradually lose out.

But inhibition has more than this to do with trial and error

learning. Not only the detailed moves, but the main activity, usually food-seeking in the animal experiments, is subjected to inhibition whenever a move results in failure. When the rat gets into a blind alley, his food-seeking may be deadened, to liven up again when he gets on the right track. A human being, in such a case, would be likely to recognize one lane as bad, and the other as good, even though he could not recall definitely which lane had led him to the goal.

Is all learning, then, simply "conditioning"? In endeavoring to formulate a theory of the underlying processes of learning, we of course try to get along with as few and simple processes as possible. We base our theory on simple types of learning, and then see whether these simple processes account also for the more complex types. Accordingly we started from the conditioned reflex, and have been trying to account for the higher types of learning as based upon the same process that appears in the conditioned reflex. Suppose our attempt has been successful, or measurably successful — does that prove that all learning is only a lot of conditioned reflexes? That word "only" covers a multitude of real differences which are blithely wished away when we say that one thing is only something else. What do those people mean who, having made the acquaintance of the conditioned reflex, proclaim that all learning is only conditioning? Do they mean to deny the superior efficacy of observant learning, or of active recitation, or of careful attention to what one wishes to learn? This is what they sometimes seem to be wishing to say. They imply that all learning would be just as successful if the learner were as passive as the dog in the conditioned reflex experiment, without any trial and error, any observation, or active participation of any sort.

But the fact is that the simple underlying processes which we have been speaking of in our theory of learning are simply the raw material for the efficient learner. It is the

learner's part to supply favorable conditions for the underlying simple processes. It is his part so to organize his total activity that the underlying processes shall have a good chance to take place. Good management of the conditions of learning is what raises learning to the human level.

The higher forms of learning are more flexible in many ways than the conditioned reflex. When, for example, paired associates have been learned, either member of a pair will call up the other; the connection works both ways, because the pair has been taken as a unit. Again, the response which becomes conditioned is not always motor, but may be a memory image, a feeling of familiarity, an attitude of amusement, an observed fact. There is a theory, to be sure, to the effect that all responses are really motor, however little they seem to be such; but this theory, which is probably not true anyway, has nothing to do with the conditioned reflex theory of learning. When you hear a person's name, and then look at his face, your name-hearing activity discharges into your face-seeing activity and establishes a connection such that the name later calls up the appearance of the face. It is the conditioned reflex sort of connection, though the response is not motor.

HABIT AND THE BREAKING OF HABIT

Any well-learned performance may be called a habit. As contrasted with an unpracticed performance, a habit is quick and smooth, easy and often only half-conscious. If we were to set about studying the formation of habits, we should simply have to review what has been said on learning.

It is more to the point to close our study of learning by some consideration of the breaking of habits. What is the process of *unlearning?* Is there anything new about it, or is it simply the process of learning, directed to a different result?

Of course, a habit might disappear through disuse, just as anything is forgotten; but the difficulty often is to

start the disuse. The habit has a hold, and does not readily let go. One who is addicted to a habit, but tries to desist from it, becomes uneasy, and yields again to the habit to avoid the present discomfort. Even such a habit as biting the nails affords some queer satisfaction to one who has that habit; it is impulsive and not purely automatic and mechanical.

The bare "will to unlearn" is not usually effective in breaking a habit, and some management is necessary. To form a counter-habit, as positive and satisfying as possible, is one rule of good management here. Taking excellent care of the beauty of the hands would be a good counter-habit for the nail-biter. We must adopt the counter-habit as *ours*, and strive for high achievement in it. If we come to realize that we have a bad habit of grouchiness, it is of little use to attempt merely to deaden this habit; we need to aim at being a positive addition to the company whenever we are present, and to practice the art of being good company. The grouchy individual hates to make such a revolution in his conduct, for he is really attached to his own grouchiness; he does the grouchiness so well, and the good-company act so awkwardly at first. But if he is really ambitious to become good company, he is on the way to lose his habit of grouchiness.

Quite a different rule of management for the breaking of a habit has been suggested by Dunlap. He came to doubt the long-accepted doctrine that repeating an act strengthened the act, and proposed to try out the hypothesis that repetition of an act resulted in either strengthening or weakening it, according to the other factors present. If the other factors present were annoyance at the act and hope of eliminating it by repeating it, he conceived that repeating the act might be the means of breaking the undesired habit. He tried out this hypothesis on the habit he had of frequently writing "hte" for "the" on the typewriter. He forced himself to write

"hte" several hundred times, always with the thought that this was an error which he would not write in the future; and found that this error actually disappeared from his ordinary typewriting. To eradicate the habit of stammering in a boy, he helped his subject to notice exactly how he spoke when stammering, and then had him reproduce the same way of speaking, criticizing and assisting him until his voluntary stammering was as nearly as possible an exact duplication of his involuntary stammering. The preliminary results of this novel treatment were favorable, though it should be added that the method has thus far not been tried extensively. Nail-biting might be attacked in the same way, the main requirement being to go through the performance cold-bloodedly but thoroughly, and with the thought that for the future this act would only be performed voluntarily.[12]

If we learn an act by doing it, to unlearn it also by doing it seems almost too good to be true. But let us remember again the extinction of the conditioned reflex. Was not that precisely what occurred in that simple case? The dog secreted saliva at the sound of the bell, but, no food following, the saliva was inhibited; and repetition of this sequence eliminated the habit of secreting saliva at the sound of the bell. It was the check-up that made the difference between strengthening and weakening by repetition. This new plan for breaking a habit is a device for managing the check-up effectively. When you write "hte" ordinarily, you pass on with the belief that you have written the word correctly, and so the error is strengthened. But when you write "hte" in cold blood, the check-up works against the habit. To bite your nails when you have a hankering for it, and to bite them in cold blood, are really very different performances in their motivation and in their outcome. If the check-up can be so managed as to deprive a habit of its fascination, certainly a long step has

[12] K. Dunlap, *Science*, 1928, vol. 68, p. 360.

been taken towards breaking the habit. However, if the matter is of serious concern, one should have the help of a psychological adviser rather than trusting to one's own unaided management.

Certainly the topic of learning is a vast field to explore. In spite of the length of this chapter and the preceding one on memory, we have only touched the high spots. But we have seen enough to be convinced that learning accounts for a large share of the development of the individual. How an individual shall act in a given situation depends on the action patterns he has learned, the facts he has observed, and the cues he has learned to respond to. Yet we can readily see that learning goes back, ultimately, to unlearned acts. Learning is modification, and there must have been something there to modify. The conditioned reflex is based upon a natural reflex. Action patterns are built up out of simpler acts. Observation depends on the possession of the senses. The individual must start with unlearned activities, and proceed from them in learning. But whether all his development, from the initial stage on, consists of learning, or whether there is also a process of natural growth, is a question still to be examined. Heredity and natural growth, then, are matters that next demand our attention.

EXERCISES

1. By comparing the various learning curves, determine (a) the form of the simple learning curve, and (b) the (two at least) types of irregularities or complications that appear in the more complex curves.

2. List all instances of learning by observation in this chapter and the one on memory.

3. What causes keep the learner on a plateau, and what causes enable him to leave it behind?

4. What is "insight" in its most elementary form?

5. Lloyd Morgan's Canon:

(a) What harm might arise from following it blindly?
(b) How is it obeyed in the formula for the learning process, as developed in this chapter?

6. Show how a memory image can be conceived as a conditioned response.

7. Show how dislike of an innocent person, or antipathy to a perfectly good article of food, might occur as a conditioned response.

8. Show that the conditioned reflex, alone, gives a very imperfect view of the whole activity of learning.

9. Make a list of subordinate laws of learning, i.e., of conditions favorable for learning.

10. What would you say in debating the assertion that "there is no learning by trial and error, but only learning in spite of trial and error"?

11. Show that both the establishment and the extinction of conditioned reflexes can be of service to the organism.

REFERENCES

A recent review of the numerous studies of animal learning is contained in M. F. Washburn, *The Animal Mind*, 1926.

A summary in P. Sandiford, *Educational Psychology*, 1929, pp. 167–253, shows the present state of fact and theory in regard to the laws of learning. See also W. H. Pyle, *The Psychology of Learning*, 1928.

A critical review of fact and theory is contained in K. Koffka, *The Growth of the Mind*, 1925, pp. 145–237, taking a point of view entirely opposed to the conditioned reflex as fundamental. The importance of the conditioned reflex is stressed by S. Smith and E. R. Guthrie, *General Psychology in Terms of Behavior*, 1921, pp. 75–133.

For experimental studies on the learning of typewriting, see W. F. Book, *The Psychology of Skill*, 1925.

Many other important references are contained in the footnotes of this chapter — and the same is true of other chapters.

CHAPTER V

HEREDITY AND ENVIRONMENT

NEITHER FACTOR CAN OPERATE ALONE, BUT THEY WORK TOGETHER DIFFERENTLY IN LEARNING AND IN MATURATION

Is a man a creature of circumstance, or the master of his fate? Is he what his heredity makes him, or what his environment makes him, or does he really make himself? The answer to all these questions is, Yes. At the outset of his career, each individual is a fertilized egg, the union of two germ cells, one from the father and one from the mother — certainly a product of heredity. What would become of this little individual, if the environment were wholly cold, barren and unstimulating? He would simply die or remain dormant. But what happens when the environment stimulates him? He responds, according to his hereditary nature, and by responding grows, develops, and makes himself over. He immediately becomes, not a creature of heredity alone, nor of environment alone, but the product of his own activity. This process is repeated at every little forward step in his development. Each step is a response *of* the individual *to* the environment, and leaves the individual different from what he was before. Heredity is never left behind, but is carried over into the developed state of the individual. The individual is the product of heredity, and equally the product of environment; he is both at once, and through and through; and therefore is nothing else, can be nothing else, than uniquely — himself.

Two knotty old problems are interwoven in discussions of this sort. There is the debate between free will and determin-

ism, and the debate between the environmentalists and the hereditarians. All these old views are in error. At least, if free will means that the individual's action at any time depends neither on the environment confronting him, nor on his own constitution as developed out of heredity by his past activity — then free will means the action of nothing in a vacuum. On the other hand, if determinism means that the environment wholly determines the individual's response, as if the individual himself counted for nothing, then determinism is only one degree less absurd than free will, and is talking of the action of nothing, though not in a vacuum. If environmentalism denies that heredity is carried along in the individual's development and remains a factor in every activity even of the adult — or if hereditarianism denies that all activity and development is an adjustment of the individual to environmental conditions — then both of these opposing views are equally impossible.

It is not necessary here to fight over these old battles, or to become blinded with the smoke of battle. Perhaps no one today holds to any of these views in the extreme form just stated, though some authorities incline more to the one side and some to the other. What we should do, instead of engaging in debate, is to examine the facts of the matter, and see as clearly as possible how the individual stands in relation to his heredity and his environment. It may be difficult to see clearly, for as we noticed before in examining the life history of a very energetic and successful individual, the heredity was good, and the environment also good, and the two factors were not readily disentangled.

ALL DEVELOPMENT DEPENDS ON BOTH HEREDITY AND ENVIRONMENT

If what we have just been saying is correct, it must be more than difficult to disentangle the influences of heredity and

environment. If every step in development is a response of the individual to the environment, then all development depends absolutely on both heredity and environment. What is true of the process of development is true of the structures developed, and of the activity of those structures. We cannot say of one structure, such as the eye, that it has grown to be what it is, a normal human eye, simply by the unfolding of heredity, for environmental stimulation has been necessary for its development. Nor can we say of another structure, such as the horny hand of the manual worker, that it is the result of environment rather than of heredity; for the skin of the palm would not be thickened by friction unless the skin had by heredity the capacity to respond in that way to that sort of stimulation. And if the eye is the result of both heredity and environment, so is seeing; if the development of the hand, with its muscles and nerves, depends on both heredity and environment, so does the action of the hand in even a learned activity such as writing.

Since, when the individual is just a fertilized ovum, all his heredity is carried in that single microscopic cell, while he may later grow to weigh two hundred pounds, it might seem that heredity could only be an infinitesimal factor in the structure and behavior of the adult. But the food which the growing organism takes in is not simply *added,* but is organized and built up into the organism. The original one-celled individual divides into two, into four, into eight — into millions, eventually — and the hereditary factor is fully present in each of these daughter cells. The relation between heredity and environment is not like addition, but more like multiplication. That is, development does not = heredity + environment, but = heredity $\times$ environment.

A little scheme which we shall use several times in the next few pages to symbolize the relation of development to heredity and environment is that of the rectangle. Let heredity be the

base of the rectangle, and environment be its altitude. Then development is the area of the rectangle, the product of base and altitude. The development of the individual depends on both heredity and environment, just as the area of the rectangle depends on both the base and the altitude. We cannot say that the area depends more on the base or more on the altitude, since if either should drop out, there would be no area left. In the same way, both heredity and environmental stimulation are absolutely necessary for life and development. If the environment should somehow cease to exist for an individual, that individual's life would cease with it; and if his heredity should suddenly cease to act, he would be but a mass of dead matter.

Another helpful analogy likens the individual's development to the running of an automobile. Which is it that makes the automobile go, the engine or the gas? Or, if both are needed, which is the more important? Well, let the engine stand for heredity, and the gas for environment, and ask the same questions. However, let us turn to some concrete evidence for the importance of heredity and environment in the growth of the individual.

To demonstrate the influence of heredity, the method of experiment is to take two individuals of different heredity, and let them develop in identical environments; if they develop differently, the difference must be due to heredity. Similarly, to demonstrate the influence of environment, take two individuals of the same heredity, and let them grow in different environments, so that any difference which results must be due to environment. These two types of experiment have been tried in many different ways on plants, animals, and human beings. The study of the intelligence of foster children, for example, belongs here. We will mention only two experiments, one of each of the main classes just indicated.

Hybrids prove the importance of heredity. If a male of

one species is mated with a female of a similar species, as a male donkey with a female horse, the offspring is called a hybrid. The hybrid, such as the mule in this case, develops characteristics derived from the father as well as characteristics derived from the mother. Now if only environment — here the prenatal environment provided by the mother's womb and body — affected development, the hybrid should follow the mother entirely, and new-born mules should be the same as new-born colts. The substitution of the male donkey for the male horse, as father, should not change the offspring, if only environment counted. But the new-born mule does differ considerably from the new-born colt, and, after birth, though the environment may remain the same for both, the mule becomes more and more a mule, and the colt more and more a horse. The special value of the experiment is that the environment is the same for both colt and mule, from the very beginning of the individual's life. Therefore the difference between a mule and a horse must be laid to heredity.

Monsters prove the importance of environment. Shall we conclude from the results on hybrids that development is simply an "unfolding" of heredity, as the name would seem to imply, with environment merely providing food, proper temperature, and other conditions necessary for life? The contrary is proved by the second type of experiment, in which heredity is left normal for the kind of animal studied, but the prenatal environment is made abnormal by introducing some unusual stimulation. The result, in general, is the production of a "monster," an individual differing in some way from the norm of the species. The special technique of abnormal stimulation differs from one experiment to another, and need not be described here, but one striking result may be cited. Nothing would seem more dependent on heredity than the possession of two eyes. We should certainly say that any two-eyed animal owed this happy state to heredity — and so it does, certainly,

but it owes its two eyes to environment as well. For if the environment, early in prenatal life, is altered in certain ways, the creature develops a single eye right above the nose. Now if the single eye results from unusual environmental conditions, the regular two eyes depend on the usual environment, no less than on heredity. Development is a response to environmental stimulation, and differs according to the stimulation received.

Shall we say then that abnormal environment prevents heredity from unfolding itself? We cannot say that, for it is just as much due to heredity that a single eye develops under certain conditions as that two eyes develop under other conditions. The single eye is the way heredity works out in response to unusual stimulation. Abnormal growth is just as dependent on heredity as normal growth, and normal just as dependent on environment as abnormal.

The conclusion that all development depends on both heredity and environment is of interest to psychology, because it holds good of the sense organs, of the muscles and glands, of the nerves and brain, and of all the structures that take part in the individual's activities. If the individual's structure depends on both heredity and environment, so does all the individual's activity. Even learning is the way heredity works out under certain environmental conditions.

However, to speak of the individual and his activities as the *passive* result of heredity and environment is a queer twist to give to the facts, for there is nothing passive in the whole matter. Heredity is not an abstract force acting upon the individual. Where does the heredity come from that is supposed to act upon the individual? The individual's heredity lies wholly within the individual. Heredity is the individual himself. And environment is not something that forces itself into the individual or is somehow added to the individual. Environment is a vast collection of stimuli that arouses the

individual to responsive activity. The individual as he stands at any moment is the product of his own activity up to that moment.

DIFFERENCES BETWEEN INDIVIDUALS MAY BE DUE TO EITHER HEREDITY OR ENVIRONMENT, OR TO BOTH

The previous discussion forces us to give up speaking of certain activities as hereditary, in contrast to other activities supposed to be environmental in origin. This distinction is an unreal one, since every form of behavior depends on both heredity and environment. The same unreal distinction has been expressed by the words "native" and "acquired." If "native" is taken to mean hereditary, and "acquired" to mean environmental, then every form of activity is both native and acquired.

At first sight, this conclusion seems to throw into the discard certain distinctions which look so sensible that we are loth to give them up. If one person has blue eyes and another brown eyes, it certainly seems that the difference is due to heredity and not to environment. If one person speaks the English language and another the Chinese, it certainly seems that this difference is due to their past social environments and not to any difference in heredity. But notice that nothing we have said requires us to deny that *differences* between individuals are sometimes due to heredity alone, sometimes to environment alone, as well as sometimes to both.

Let us go back to our simple analogy of the rectangle. Though it would be absurd to suppose that the area of the rectangle depended on the base alone, or on the altitude alone, there is nothing absurd in saying that two rectangles differ in area because of a difference in the base alone, the altitude being the same for both. In the same way, though it would be absurd to speak of the automobile as running by the engine alone, or by the gas alone, it may still be true that the dif-

ference between the performance of two automobiles is due wholly to a difference between their two engines, as both are burning the same gas — or wholly to the gas used, as the engines are identical. If two human individuals are acting differently, it may be because the individuals differ, or because they are receiving different stimuli, or both. And if two individuals have developed differently, it is because of differences in heredity, or in environment, or in both.

How to distinguish native from acquired differences. Though it will not do to speak of native structures and of acquired structures, nor of native as against acquired forms of activity, it is perfectly sensible to look for native or hereditary differences between individuals, and for differences that are acquired or due to environment. The distinction is sound enough, but there may be much difficulty in deciding whether a given difference between individuals, in intelligence or character, for example, is native or acquired. The way to investigate the question is to follow the same logic that guided the experiments already described on prenatal development. If we can be sure that two individuals have had the same environment, then we can attribute their actual differences to heredity; or if we can be sure that they have the same heredity, then their differences must be due to environment.

The logic of the problem is simple enough, but the difficulty remains of making sure of equal heredity or of equal environment. It is not safe to assume that even brothers or sisters have the same heredity or the same environment. Their heredity is more alike than that of unrelated children, but it is not identical, as we see from the fact that they may differ in hair color or eye color. One child may take after the father and the other after the mother. The heredity passed on by either parent to the child is complex and not the same for all the children, and the combination of heredity from the two parents is still more variable. On the side of environment, the same home is not

the same environment to the oldest child and to the second. The children are not and cannot be all treated alike or stimulated alike. The different performances of two children from the same family may be due, then, either to differing heredity or to differing environment or to both.

To reach scientific certainty in this matter, then, we are forced to experiment under carefully controlled conditions, such as the biologists use in studying Mendelian inheritance. Often, however, we can be practically certain of all the sameness we require in heredity or in environment. Though the heredity of a Chinese child and of an English child are certainly not identical in all respects, we know that they are sufficiently alike to enable either child to speak either language, and consequently we are sure that the difference in the language they actually speak is due to environment. On the other hand, though a child from a good home and one from an undesirable home have different environments in many respects, they both have plenty of opportunity to notice that a man's arms come out from his trunk and not from the side of his head, and therefore if one child of six years in the man-drawing test draws then one way and the other the other way, we attribute the difference to heredity; but we are not quite certain here.

About the best way to insure equal environmental opportunity (in typewriting, for example) is to train the individuals to be compared to their respective limits, so that each has all the opportunity he can use. Then, if heredity counted for nothing, we should expect the individual differences to disappear. Now it is not always true, by any means, that the person who starts best in a given performance comes out on top at the end of intensive training, but it is always true after training that some persons are far superior to others. While, then, no one could doubt that individuals differ largely because of such environmental factors as opportunity and incentive, the

evidence is that differences in heredity are important, too, in producing the unequal performance of different individuals.

Sex differences. Not only differences between individuals, but differences between groups, may be due to either heredity or environment. As regards the races, it appears certain that some physical differences are hereditary, but when we come to mental differences the matter is by no means clear, since the children of one race grow up in a different cultural and social environment from the children of another race. In discussing the differences actually found in test scores between different racial groups, we pointed out, once before, the great caution necessary in interpreting the results. But as between the sexes, since both boys and girls grow up in the same environment, one would at first think it safe to assume that the differences which appear are due to heredity. There is a difference in heredity, since the sex of each individual is already determined in the fertilized egg. Each individual's sex is determined at the very start of his or her individual existence. The primary physical differences between the sexes, then, are due to original nature and not to environment. And there are some secondary characteristics, such as the plumage of birds, that are sex-linked. In the human species, differences in size and build are the most obvious.

It must be understood that a sex difference is usually simply a difference on the average, with much overlap of individuals. Some women are taller than some men, some men are plumper than some women. While men average two or three inches taller than women, some men are eighteen inches taller than some other men, and the range of individual women is about as great. In general, any sex difference is small in comparison with the range of individual variation within either sex.

In performance, the greatest difference is certainly woman's absolute superiority in the bearing and early nourishing of

children. Apparently she is superior also in almost everything that has to do with little children, though it must be said that in some primitive peoples men participate more fully in the care of little children than is customary with us; so that the true sex difference may not extend so far as might be inferred from our customs. Woman's greatest inferiority is probably related in some obscure way to this her greatest superiority. Woman is inferior in muscular strength, not so much in endurance as in intensity of muscular action. This difference can scarcely be due to differences of occupation, since it appears even in those tribes where the women do much of the hard labor. Men's muscles use fuel and oxygen more rapidly than women's, and the red corpuscles of the blood, which carry oxygen from the lungs to the muscles, are ten percent more abundant in men than in women.

It is quite possible that the sex differences already mentioned are responsible more or less directly for all the important differences found between men and woman, in occupations, interests, skill and knowledge. If so, most actual sex differences are not forced upon people by either heredity or environment, but simply represent the way heredity most easily works out in the social environment. Most actual sex differences, then, would be not necessary differences, but lines of least resistance.

There is, however, one other difference which is due to heredity, and which is of some social importance, and that is the more rapid maturing of girls than of boys. Girls reach sex maturity and adult stature a couple of years younger than boys, and it is quite probable, though not certain, that they reach mental maturity earlier.

In intelligence tests of the Binet type, girls show a slight superiority over boys of the same age, while in performance tests the slight advantage is with the boys. On the whole, there is little indication of a sex difference in intelligence.

Memory tests show a sex difference in favor of the girls.

Their memory span averages longer, and their learning of either nonsense or logical material is more rapid.

Girls seem to have a definite advantage in all sorts of language activities. They start talking in childhood about a month earlier, on the average, and pick up a vocabulary more rapidly in the next few years, and they use longer sentences as little children. In school they surpass the boys in language work. And they surpass in various language tests, such as naming as many words as possible in three minutes, or giving the opposites of words given them, or color naming. This last test presents five familiar colors, each repeated on a sheet twenty times and mixed with the others in irregular order. It is not a question of knowing the five color names, but of fluency in using them in rapid succession, and girls and women show a marked superiority to boys and men in this test. The difference may have something to do with the color sense, as well as with facility with the tongue, for it is a fact that color-blindness is almost unknown among women, while it is definitely present in three or four percent of men. This difference in frequency of color-blindness is certainly a native sex difference. Yet most men test out as well as women in color discrimination, so that the difference in the color-naming tests seems to be more a linguistic difference between the sexes than a sensory difference.

Boys surpass girls in the tests that have been prepared for general information; and, in school, while girls surpass in the language subjects, boys carry away more information from such subjects as geography, history, and the sciences.

Boys surpass in most motor and manipulation tests, though decidedly not in handwriting. Their superiority in managing mechanical contrivances is marked. Can we accept this difference, or the girls' advantage in language and memory, as a native sex difference? There really is no good evidence on this question. Certainly boys get more experience with tools

and mechanical toys, but this seems to be because they naturally take more interest in them. Yet the difference in interest may result from the influence of adults and older children, and from what is customary and expected of each sex. Young women learn to drive cars nicely, but they seldom bother with the machinery of the car, or even to change tires. Somebody is always glad to do it for them, while the young men have to depend on themselves in such matters. In the same way, men's unhandiness in sewing or cooking or minding babies may be due to somebody else's being willing to take these jobs off their hands. Since women like to serve men, and men to serve women, this sex interest, derived more or less directly from the primary difference of sex, operates to create large differences in the actual performance of the sexes.

In general, we may conclude that there are some large and probably some minor differences between the sexes that are truly native, but that, as these native differences work out in the social environment, they create secondary differences of opportunity and incentive, and so of occupation and performance.[1]

HOW UNIFORMITIES OF BEHAVIOR CAN BE PRODUCED

In spite of all the differences which we have been laboring to explain, is it not true that people are, after all, very much alike both in their structure and in their behavior? They breathe alike, they eat very much alike, they alternate between sleep and waking, they pass through the same stages of growth, maturity and senility, they talk and dress and conduct themselves in a fairly uniform manner, at least within the same social group. Now if differences may be due to either heredity on environment, to what are uniformities due?

[1] References on Sex differences: A. T. Poffenberger, *Applied Psychology*, 1927, pp. 120-132; F. L. Goodenough, *Psychological Review*, 1927, vol. 34, pp. 440-462; E. A. Lincoln, *Sex Differences in the Growth of American School Children*, 1927.

We easily fall into the error of saying that some uniformities are due to heredity, and others to environment. Two modes of transmission are spoken of by which uniform behavior is handed down from generation to generation. Reflexes and instincts are said to be handed down by heredity, while language and customs are handed down by social tradition. Or, again, biological uniformities are said to be transmitted by the germ plasm, and cultural uniformities by the social environment.

But this manner of speaking runs counter to our previous decision that all behavior depends on *both* heredity and environment. Let us go back once more to our analogies. Two rectangles cannot be the same in area just because they are the same in one dimension; they must be the same in both, or else differences in the one must be compensated by opposite differences in the other. If we find two rectangles that are equal in area, and are informed that they are alike in one dimension, we can infer that they are alike in the other also. It is the same with the automobiles. If two automobiles are alike in their performance, and we know that their engines are alike, then we can be sure they are burning equally good gas. By the same logic, if two individuals develop alike, or behave alike, and we know that their heredities are equivalent, we can be sure that they have been exposed to equivalent environments; or if we know that two like individuals have had like environments, then they must have had like heredities. Uniformity in development or behavior means, not that either heredity or environment have been alike, but that both have been alike, or else that the difference in heredity has been balanced by a reverse difference in environment.

For example, the striking uniformity that exists in number of eyes means, no doubt, that all men, indeed all vertebrates, have a uniform heredity in this respect, and also that the vast majority of them pass through the early stages of develop-

ment under environmental conditions that are sufficiently alike to enable heredity to work out in this uniform way.

An example of a different sort is afforded by the use of the bow and arrow in nearly all tribes and peoples, the world over, prior to the introduction of firearms. This would be called an instance of social transmission, but it demands also sufficient uniformity of heredity to enable men of all races to make and use the bow and arrow. None but human beings have the heredity to enable them to pick up this mode of behavior. Even the chimpanzees have not picked it up from their human neighbors.

The uniformities which are said to be transmitted by heredity do not demand any learning by the individual, while those which are socially transmitted do require learning. That seems to be the psychological difference between the two.

Compensating or regularizing influences of heredity and environment. The fact of regularization or standardization is as curious as any we have met. The environment actually makes people more alike than their heredities would warrant. Heredity also has a regularizing influence, and keeps individuals more alike than their differing environments would lead us to expect.

Individuals of unequal heredity, exposed to equal environmental stimulation, ought to develop unequally; and precisely this is the fact. Two children, one of low and the other of high IQ, placed in the same unstimulating environment, will learn little, but the brighter will learn the more. Transfer them to a stimulating environment, and they will both learn more, but the bright one will still learn more than the dull. Improve education for all, and you may improve everybody, but you probably would leave them as unequal as they were.

But the same social group — family, school, gang — is not the same social environment for individuals of different heredity. Decidedly not. The social environment consists of people

who behave differently towards an individual according as he is strong or weak, bright or dull, adventurous or timid. By treating different individuals differently, the group accentuates their native differences in some respects, making one the leader and another one the comedian, but in other respects it enforces conformity to its customs and standards, and thus makes the individuals more alike in conduct and achievement.

The school, for example, enforces standards of achievement. Those children who meet the standards easily do not need prodding, while those of less ability receive extra attention, in order to bring them up to standard.

The same is true over a wide range of skills, manners and morals. The social environment sets certain standards, not too high for most individuals to reach with ease, and forces conformity with these standards, by bringing pressure to bear where it is needed. The standards are uniform, but the pressure needed to bring all individuals up to standard differs with the individual, and compensates in a measure for native differences.

Heredity also has its standards, and its ways of compensating for the differing environments to which individuals are exposed. The facts known by the biologists under the name of " regulation " belong here. In some low forms of animal, a leg which is pulled off is replaced by a similar leg. In the higher animals, regeneration does not go as far as that. But the skin regenerates over a wound, and a broken nerve regenerates and connects again with the muscles, so that the paralysis that followed the injury disappears. Recovery from infection and disease is a similar example. It is " nature that cures," it is heredity, compensating for abnormalities of the environment, that brings the individual back to normal, and makes him more like his fellows than the accidents of environment would have left him.

Another sort of regularization due to heredity, and a sort

that has much to do with human behavior, is what we know as forgetting, or atrophy through disuse. Adults are more uniform in their knowledge of Latin — or lack of knowledge — than can be accounted for by their previous environments. The same is true of muscular strength. Two men who, from unequal training in athletics, are very unequal in muscular development at the age of twenty, may become about equal at forty. Thus the natural process of forgetting irons out differences due to earlier environment.

To sum up this discussion of uniformities of behavior, we may say that neither uniform heredity nor uniform environment alone can give uniform development and behavior. Both must be uniform, or else the differences in the one must be compensated by differences in the other. As a matter of fact, both heredity and the social environment have ways of producing compensation and bringing diverse individuals to a standard or norm.

THE TWO TYPES OF DEVELOPMENT: LEARNING AND MATURATION

Let us use learning in the broadest possible sense, to cover all modification of structure or of activity through exercise. Exercising a muscle develops it and increases the strength of its later activity, and this development through use or exercise we will include under learning, along with all the other varieties surveyed in the preceding chapters.

It appears to be a general principle of life that the exercise or "functioning" of any organ develops the organ, unless it is already well developed, and maintains it in good condition if it is already well developed, while prolonged inactivity results in loss of good condition and finally in atrophy through disuse. One of the clearest cases of this growth through exercise is seen in the recovery of a convalescent's strength, or in the recovery of an arm that has been kept immobile in a cast for days and weeks. But all learning is certainly development,

and it certainly is the result of exercise, of going through the performance to be learned. Let us set it down then, that one kind of development is development through exercise, and let us call this kind of development *learning.*

But is all development due to the exercise of the structure to be developed? It would appear that any structure must have developed to a certain point before it can begin to act or function. The muscle must develop to the point of being a little muscle, before it can act as a muscle. It cannot get the benefit of exercise till it has become capable of functioning. The same with the eye, or with a nerve or nerve center. Therefore there must be a kind of development prior to exercise, and not dependent on exercise. Let us call this primary development by the name, *maturation,* which means " maturing."

We have to reconcile this distinction, however, with our previous conclusion that all development was a response to stimulation. It will not do for us now to think of maturation as the unstimulated unfolding of heredity, nor of learning as due entirely to the influence of the environment. Learning depends on heredity, as well as on stimulation from the environment. Probably we are already clear on that point. But this other sort of development, that is prior to exercise, how does that depend on the environment? Well, we saw in the case of the one-eyed monster that abnormal stimulation gave abnormal development, whereas normal stimulation gave the normal result. Growth is an active response of the individual to stimulation received.

Growth is of course a form of activity, but it is distinctly not the exercise or functioning of the growing structure. The abnormal development of the eye did not result from abnormal use of the eye. The eye develops from a mere rudiment to a complex structure capable of use, while it is still shielded from practically all light. The stimulation it receives before birth is not the stimulation of light, but probably some sort of

gentle chemical and electrical stimulation from the structures about it. It responds to such stimulation by developing, but certainly not by seeing. When light does enter the eye, after birth, the eye is ready to respond by performing its own proper function, that is, by seeing, and is no doubt further developed and perfected by this actual exercise. The lungs afford another convincing instance of development preceding function. No breathing can possibly occur before birth, nor can any air reach the lungs to distend and exercise them, and yet they develop to a complex structure ready for use. As soon as breathing does start and air does enter the lungs, the lungs are further developed by exercise. The most precise statement of the whole matter is this: all development is a response to stimulation; but there are two sorts of stimulation that arouse this response. One sort of stimulation seeps into any organ from the surroundings, and the other sort is stimulation by the exercise of the organ itself. Maturation is growth of a structure in response to the diffuse stimulation received from its surroundings, while learning is growth in response to the functioning of that structure.

Let us illustrate the distinction between maturation and learning yet again by the development of a muscle. In the early development of the individual, long before birth, a muscle first makes its appearance as a little rudimentary structure having as yet no contractile power. This rudiment receives diffuse stimulation from the surrounding tissues and from outside of the developing individual, and its response to this stimulation is to develop into a real muscle, with contractile power. Along with the muscle develops its nerve, connecting it with the nerve centers and indirectly, by other nerves, with the sense organs. When this maturation has gone far enough, the muscle begins to receive definite stimuli from its nerve, and to respond by contracting. This contraction is the function or exercise of the muscle. The contraction of the muscle is

itself a stimulus to further development. From that time on, maturation is supplemented by development resulting from exercise.

What is true of the muscle, or of the eye, is true also of the brain. The brain starts developing very early in prenatal life, and develops very rapidly, as we can see from the large size of the new-born infant's head in relation to the size of his whole body. Not only the external form of the brain, but also its enormously complex internal structure are pretty well laid down before birth. As it can have little exercise before birth, most of this prenatal development must be credited to maturation. But as soon as the infant begins to take notice, and to do things, the brain is exercised in different ways, and develops accordingly. Definite brain mechanisms for the execution of learned acts are developed by exercise out of the incomplete and plastic structures laid down in the process of maturation.

Learned and unlearned activities. Psychology is only indirectly interested in structures and their development. Its interest lies in the activity of the individual, but, because activity depends on structure, it wishes to know how the structure develops. So the two modes of development, maturation and exercise, are of psychological concern.

We dwelt long on learned activities, and are now brought to the point of recognizing unlearned activities as well. The activity of a structure that has developed entirely by the process of maturation is an unlearned activity. Breathing, such as occurs right after birth, is an unlearned activity, and so is crying. As soon as breathing and crying have been strengthened by a little exercise, they are no longer wholly unlearned, though still mostly so. Modified ways of breathing and crying, which appear later, have more of the factor of learning behind them. Any originally unlearned activity, by repeated exercise, becomes partly a learned activity. Evidently no activity can be *wholly* a learned activity, since no structure

can have been developed wholly by its own exercise, without prior maturation. Learned actions, in fact, are modifications and combinations of unlearned actions.

The distinction between learned and unlearned actions might seem to have broken down, since no action can be wholly learned, and no action can be wholly free from the effect of previous learning, except the first time it occurs. But if all the modification that has occurred consists in strengthening the activity, or in making it a little more regular, we can continue to call it unlearned, in distinction from the many other activities which have been greatly modified, or even built up out of simpler activities, in the process of learning.

But how can we tell whether an activity is learned or unlearned, or how far it is unlearned and how far learned? We have to proceed by the genetic method, fortified by experimentation. We have to note the first appearance of the activity in the individual's life, and the changes produced in it by its exercise. We have to rule out the possibility of learning, by excluding the conditions under which learning occurs, and see whether the activity still makes its appearance. For example, to discover whether the flow of the dog's saliva at the smell of meat is a natural or a conditioned reflex — an unlearned or a learned response — we have to raise a puppy well into the meat-eating age without ever allowing him to eat or smell meat. Then we let him smell meat, and observe whether there is a resulting flow of saliva. If there is, it must apparently be an unlearned response; if there is not, then we should feed the puppy the meat after allowing him to smell it, and repeat this procedure a few times, to see whether, with this opportunity to learn a conditioned response, the response is actually learned. If so, our demonstration of the learned nature of this response is complete; but if not, we have evidently tried our experiment too early in the puppy's life, and must wait for further maturation to occur before settling the ques-

tion. The general logic of this line of investigation is that unlearned activities are those which develop when the possibility of learning is excluded.

LEARNING AND MATURATION BEFORE BIRTH

Though it is easy to assume that the child learns nothing before birth, and that all the activities of which he is capable at birth are unlearned, this assumption may not be wholly correct, and at least we should consider whether the conditions of the child's prenatal life make learning impossible.

The unborn child leads a very sheltered existence. The stimuli that can reach him are few and vague. Light is practically excluded, sound very nearly so, and odor and taste. Temperature is too uniform to constitute a stimulus, and pressure on the skin likewise, except as the child moves himself. But from about the middle of his prenatal life, the child has spells of muscular activity, often several such spells a day. His movements may stimulate his sense of touch and also his muscle sense or sense of movement. These senses, as well as his muscles, are probably strengthened by the exercise received.

Can we suppose conditioned reflexes to be established before birth? It seems possible that his movements might become attached to the stimuli just mentioned. If he pushes down his foot a little and immediately draws it up again, the second movement might become attached to the "feeling" of the first movement, and so a tendency might develop to move his foot up and down rhythmically. But it is very doubtful if this kicking movement has to be learned. Apart from such simple motor sequences, very little, it would seem, can be learned in the way of conditioned reflexes before birth. Since he has little leeway for movement, the main thing which he might learn is to restrict his movements.

It must also be remembered that the child sleeps most of the

time right after birth, and apparently before birth as well, and the conditioned reflex experiment indicated that the waking condition was necessary for learning. It may fairly be concluded that the child's development before birth depends on maturation, with some strengthening of a few activities by exercise, and that the repertory of performances which he displays at birth consists of unlearned activities.

An experiment on early maturation. Experiments on learning and maturation have not been tried on unborn human children, but here is an experiment on the corresponding stage in frog development, to convince the doubters who may still be very skeptical of maturation apart from exercise. Frog's eggs, placed in a dish of water, develop into little tadpoles, which after a time begin swimming around. If a small amount of the drug, chloretone, an anesthetic, is dissolved in the water, the eggs develop normally, but the tadpoles remain motionless. As far as visible structure is concerned, they are ready to swim as soon as the drug is removed; but will they be able to start right off and swim, without going through a process of learning to use their swimming organs? Well, here is the experiment. A bunch of frog's eggs was divided into two groups, one of which was placed in the drugged water, and the other, the "control group," in plain water. Both dishes were kept side by side under the same conditions of light, temperature, etc. After some days, the control group began to swim, while the drugged group, though at the same stage of structural development, remained quiet. But now the drug was washed out with plain water, and within a few minutes the previously drugged tadpoles were swimming just the same as the control group. They only needed to have the anesthetic removed, they did not need to learn the use of their swimming organs. Maturation of the structure was at the same time maturation of the function.[2]

[2] L. Carmichael, *Psychological Review*, 1928, vol. 35, p. 255.

Unlearned activities present at birth. Besides the elementary movements of arms and legs, trunk and head, we find in the new-born infant the remarkably strong grasp of the hand upon a finger or stick placed in it, a grasp strong enough to support the child's weight. Then we have more complex movements, such as breathing, crying, and sneezing. Sucking and swallowing form perhaps the most complex action pattern present at birth. All the senses function either at birth or soon afterwards, and the eyes turn toward a light. In short, the infant has quite a stock of unlearned activities with which to begin his learning process.[3]

LEARNING AND MATURATION IN INFANCY

Is maturation left behind at birth, and is all the development of activity that occurs from that time on to be counted as learning? The first answer is that we should not exaggerate the importance of birth itself. There is no tremendous revolution in the child at the moment of birth, as if he had finished one definite stage in his development and now struck out on a new line. The same processes go on as before, with more exercise coming in and gradually increasing in importance.

Birth does not come at the same stage of development in all animals. Compare the guinea pig and the white rat, two laboratory animals that are very well known. The new-born rat has no hair, it can barely crawl, cannot right itself if placed on its back, and is entirely helpless and dependent on its mother for many days. The guinea pig is born with nice fur, and fully able to run about; it starts to nibble green things within a day or two. The new-born kitten is intermediate between the rat and the guinea pig in its stage of development at birth. Now which is the more probable view — in advance of rigid experimental proof — that the rat has to learn many

[3] J. B. Watson, *Behaviorism*, 1925, pp. 87–103.

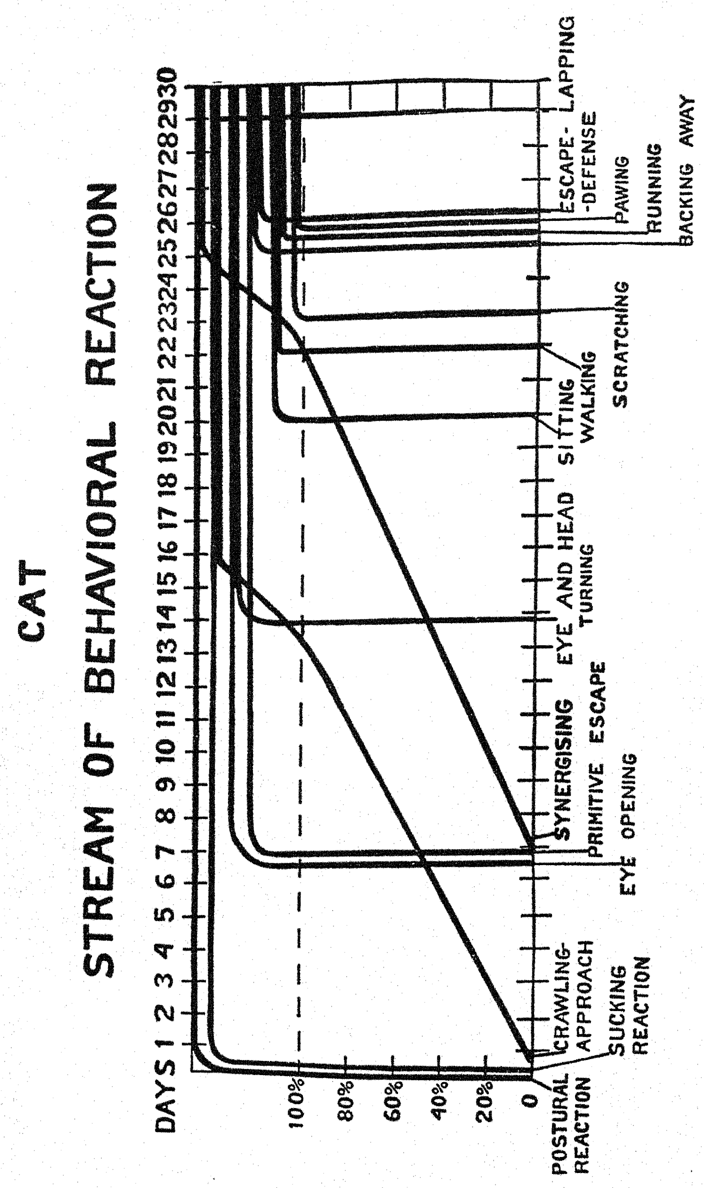


FIG. 17. — (From F. Tilney.) The time after birth when different elements of a kitten's behavior make their appearance. An activity which comes in gradually is indicated by a sloping line. There are definite developments in the brain that account for the sudden emergence of some of these behavior patterns.

performances, such as walking, which the guinea pig gets by maturation, or that more of the maturation process goes on in the rat after birth than in the guinea pig?

We see similar differences in different species of birds at the time of hatching. While the little chick walks and feeds itself from the start, the young dove is helpless and has to be fed by the old birds. Here again, does it seem more likely that one species has to learn what a closely related species gets by maturation, or that the maturation process simply proceeds further within the egg in one than in the other?

The human infant is born in a very immature state, and requires an exceptionally long time to reach even partial independence of the mother. The whole period of growing up is extremely long in man as compared with most other animals. And yet the human infant has more power of learning than other animals. If development after birth depended wholly or mostly on learning, human growing up should be rapid instead of slow. Some psychologists like to draw the conclusion that human development is slow just because it depends entirely on learning, without the benefit of the maturation process which contributes to animal development. This cannot be altogether true, since human development is slow in such matters as growth in size, cutting the teeth, and puberty, which are certainly not matters of learning. The rate of maturation, in such matters at least, depends on chemical regulation by some of the glands within the body. It is certain, then, that maturation plays a role in human development, after as well as before birth, and that it is a slow process in the human species. It is almost as certain, too, that the brain, nerves, muscles and sense organs develop partly by maturation during childhood and youth.

The slowness of maturation in the human child, along with his great learning power, makes for a combination of the two sorts of development that is characteristically human. While

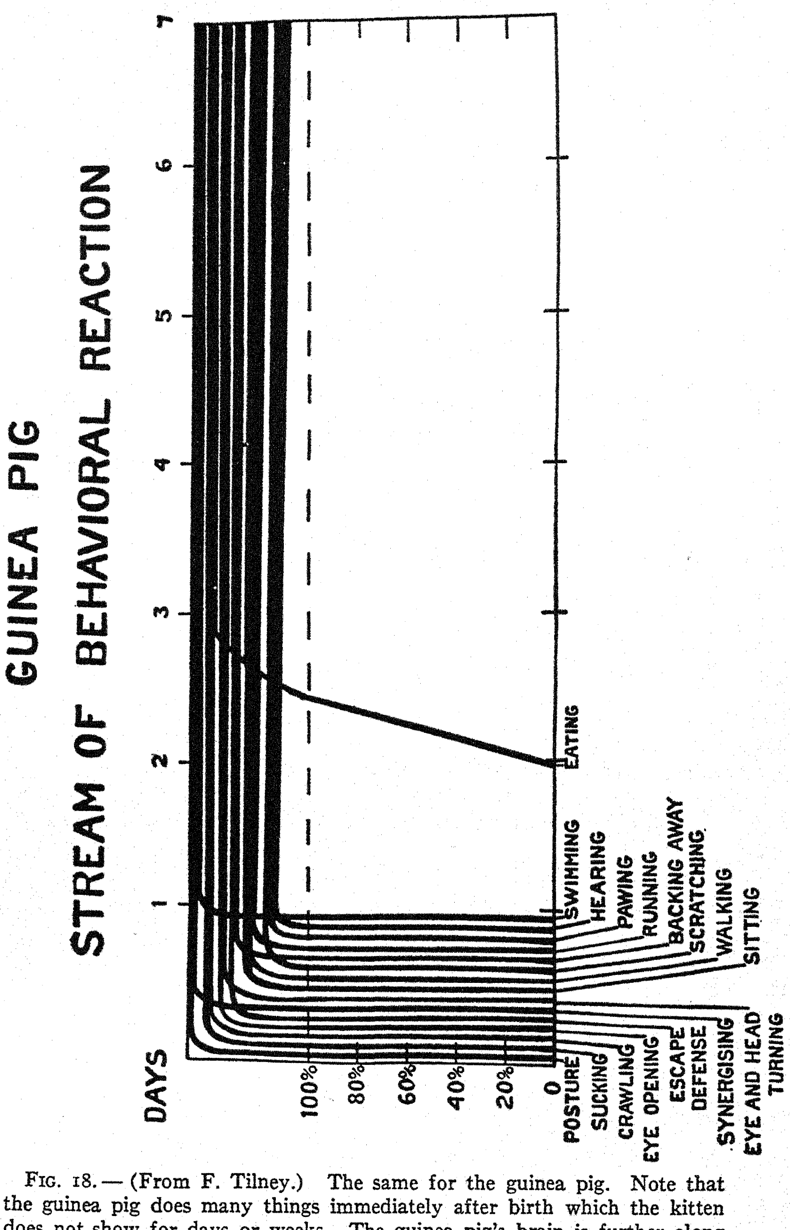


FIG. 18. — (From F. Tilney.) The same for the guinea pig. Note that the guinea pig does many things immediately after birth which the kitten does not show for days or weeks. The guinea pig's brain is further along in its development at birth.

the child is growing, he is learning, and his activities, laid down in the rough by maturation, are given more precise form by learning. The speech organs, for example, develop by maturation, but the exact ways in which they are used are determined by learning. The prolonged period of human infancy gives a chance for the social environment to exert a powerful influence on the individual's behavior. By the same token, we are sure to find it very difficult to separate learned from unlearned activities in human beings. Since learning is a factor in developing almost all human activities, some authorities, rather weakly, simply ignore maturation and lump all activities together as learned, unless they are fully developed before birth.

Maturation prepares the raw materials for learning. It provides weak activities that are strengthened by use, and variable activities that are regularized by use. It provides smaller activities that are combined by learning into larger action patterns, and it provides broad, diffuse movements that are broken up by learning into more minute and precise skilled movements.

Let us examine a few of the activities of infants, with the question in mind, how far they are learned and how far unlearned.

Feeding. The food-taking activity of the new-born infant is really a very complex series of movements: lip and cheek movement in sucking, followed by tongue movement forcing the contents of the mouth back into the throat; then a squeeze by the throat, with the openings to the mouth, nose, and lungs closed off and the opening towards the stomach open. Let no one say that the infant is provided only with simple, crude or chaotic movements, for this one at least is complex and closely knit. But the sucking movement may be weak at first, and not readily aroused. A little practice strengthens it and makes it more dependable. Learning thus comes in to a slight extent

to perfect the unlearned movement, while leaving its organization unchanged.

The sequence of movements that takes food into the mouth and carries it to the stomach is, however, not the whole of the feeding activity. The first step towards taking food is the condition of hunger, a chemical state of depletion of the food substances already in the body. Hunger gives rise to stomach movements, which can be felt as hunger pangs. This organic state, and these hunger pangs, arouse the infant to restless movements of the arms and legs, head and trunk, often accompanied by crying. In many young animals, definite food-seeking movements come in here, but in the human infant this part of the whole feeding activity is rather indefinite at first, but it takes shape in the course of a few weeks. The baby learns to stop crying when taken up, his head movements towards the nipple become definite, and his hands often participate in a movement towards the food. Taking the whole chain of activities, then, we see that the first links in the chain (organic hunger, stomach movements, restless movements and crying) are unlearned, and that the last links (sucking, swallowing, and digestive processes) are also unlearned, but that the middle of the chain (the food-seeking) is largely learned.

With the maturation of the teeth, the biting movement, fundamentally an unlearned movement, comes in for a lot of exercise. The movement of the hand to the mouth seems to be learned by trial and error and selection from the varied hand and arm movements that the baby makes from the start. So the ground is prepared for the transition from the sucking to the chewing form of eating. The ways of getting food to the mouth, and, later, the ways of finding and preparing food, are certainly learned by the human child. Learning fills in the gap in the unlearned feeding activity, between hunger and actual eating.

In contrast to the human infant, the chick has the whole

chain of feeding activity well organized by maturation. Once before we appealed to the chick for instruction; we noticed that his pecking was at first inaccurate, but rapidly improved with a day or two of practice. If the chick is prevented from pecking at anything for a few days, his first attempts, after this delay, are no better than those of the newly hatched chick, but he gains more rapidly with practice.[4] We can derive much instruction from this simple experiment. In the first place, we see that exercise must be added to maturation in order to perfect the act of pecking. In the second place, since the older chick learns more rapidly than the younger one, we see that some maturation has taken place during the few days since hatching. Undoubtedly the muscles and their nerve connections have improved during the growth that has occurred. In the third place, it is interesting to notice what a complex and highly coördinated performance this unlearned form of feeding is. Legs, trunk, neck, bill work together in proper time and measure, in response to a stimulus received by the eye, the sight of the grain. This complex, well-organized movement is not learned; but learning has to tune it up. Learning does one thing more. At first, the chick pecks indiscriminately at any small object. If it gets hold of a hairy caterpillar, it rejects it, and soon learns not to peck at caterpillars. Here, as often, maturation provides a mechanism that will work, but learning makes the mechanism stronger, more precise, and more discriminating.

Locomotion. Every creature has its own way of moving from place to place, and in most species it is clear that its mode of locomotion is provided by maturation, and does not need to be learned. The guinea pig, as we noticed before, walks at birth. The rat can barely crawl at birth, but as soon as its nervous system and muscles have developed to the same stage

[4] Breed & Shepard, *Journal of Animal Behavior*, 1913, vol. 3, p. 274; C. Bird, *Pedagogical Seminary*, 1925, vol. 32, p. 68.

that we find in the guinea pig at birth, then the rat, too, stands up and walks.

Consider the question whether birds learn to fly, or simply come to fly when maturation has gone far enough.

The newly hatched bird cannot fly; its muscles are not strong enough, its wings are not feathered, and its nerve mechanism for coördinating the wing movements has still some growth to make before being ready for use. But, under ordinary conditions, the young bird has some chance to *learn* flying, by watching the old birds fly and by trying and gradually getting the motion. The old birds, after a time, push the young ones from the nest and seem, to our eyes, to be teaching them to fly. Experiment enables us to decide the question. One of the earliest experiments in animal psychology was made by Spalding in 1873. He took newly hatched birds from the nest and shut each one separately in a little box that gave it no chance to stretch its wings or to see other birds fly. Here he fed and cared for them till the age at which flying usually begins, and then released them. Off they flew, skilfully managing wings and tail, swooping around the trees and soon disappearing from sight. A very successful experiment! — and conclusive. The little birds had had no chance to learn to fly, yet they flew. Flying must have come to them in the natural course of growth.

Now let us turn to the more ticklish question, whether the human child learns to walk. We think the child learns to walk because it begins very imperfectly and usually takes several weeks before it can be described as really walking of itself. We even think we teach it to walk, though when we examine our teaching we soon convince ourselves that we do not know *how* we walk, and that what we are doing with the baby is to stimulate and encourage him to walk, protect him from hurting himself, etc., rather than to teach him as we later teach the child to write. An experiment to settle the matter might be

conducted along the lines of Spalding's experiment on the young birds. We might prevent the baby from making any attempt to walk till it had fully reached the normal age for walking, and then turn it loose and see whether it walked of itself.

Such an experiment has never been made under strict laboratory conditions; but here is a well-attested case that approximates to an experiment. A little girl of seven months, a very active child, seemed to want to get on her feet; but the doctor decided that her feet were too small to use, and directed that she be put back in long dresses. For four months she was kept in long dresses, and great care was exercised never to place her on the floor without them. Then, one day, she was set down without her dress, and immediately up she got and walked; and from that moment she was very agile on her feet.

There are a few other cases, differing in details, but agreeing on the main point, that the baby walked well on its first trial and went through nothing that could properly be interpreted as a process of learning.

It would really be very surprising if the human infant were left to learn locomotion for himself, while all other animals have this power by nature. Just because the human infant matures slowly, and learns a vast deal while maturing, is no reason for overlooking the fact that it does mature, i.e., that its native powers are gradually growing and reaching the condition of being ready for use.

Walking, to be sure, does not spring suddenly from nothing. Walking combines several movements which develop earlier. Alternate motion of the legs appears very early and is much exercised long before walking appears. Holding up the head, sitting up, creeping, and standing, are usually in use before walking starts. Walking combines balancing, standing and alternate leg movement. We may be inclined to admit that the part activities are unlearned, while insisting that their

combination is learned by trial and error. However, it is at least equally probable that the integrating nerve mechanism, that harnesses the several part activities into the total activity of walking, is laid down in the maturation of the human nervous system, as it certainly is in animals. There is, of course, no doubt that walking, once started, is strengthened and steadied by exercise.

Voice and speech. To discover whether the song of the oriole is fixed by nature or learned by imitation, Scott took some little ones, just hatched, and brought them up away from older birds. After a time, when growth had advanced to a certain stage, the birds began to sing. The elementary notes and rattles characteristic of the oriole made their appearance, but were combined in unusual ways, so that the characteristic song of the oriole did not appear, but a new song. When these birds had grown up in the laboratory, other new-hatched orioles were brought up with them, and adopted this new song; so that the laboratory became the center for a new school of oriole music.

Probably this last is about the result one would get in the analogous case of human speech, if a similar experiment should be tried on children. Without an experiment, we have certain facts that point to a conclusion. The child uses his vocal organs from birth on; and before he reaches the age when he imitates the speech of others, he produces various vowels and consonants, and even puts them together into simple compounds, as "da-da" and "goo-goo." So far, deaf children do about the same as others, affording additional evidence that so much of speech is unlearned. To get real talk, however, further combinations of the speech movements must be made, and the combinations (words) must have meaning attached to them. These higher achievements are evidently the result of learning, since the child uses the words that it hears spoken, and attaches the same meanings to them as people do about it.

An interesting fact, which may have some bearing on the

question how far walking is learned, is that bright children on the average learn to walk earlier than dull children. The bright children also learn to talk earlier than dull children, and the difference is greater in age of talking than in that of walking. Most children start to walk a month or two younger than they start to talk, but extremely bright children start talking, on the average, a month or so before they start to walk. The following figures give the approximate averages for considerable numbers of children, of different grades of intelligence:

AVERAGE AGE OF STARTING TO WALK AND TO TALK

	Started to walk	*Started to talk*
Very bright children	13 months	11 months
Moderately bright children	14 "	16 "
Morons	22 "	34 "
Idiots	30 "	51 "

Data on very bright children from L. M. Terman, *Genetic Studies of Genius*, 1925, vol. I, p. 186; on the others from C. D. Mead, *The Relations of General Intelligence to Certain Mental and Physical Traits*, 1916, p. 22.

It is doubtful, however, whether these results can be used to bolster up the view that walking is essentially learned, since even teething shows something of the same difference, feeble-minded children being late in cutting their teeth.

LEARNING AND MATURATION IN CHILDHOOD AND YOUTH

After the child has started to walk and to talk, there are few specific movements regarding which the question is likely to be raised, whether they are learned or not. Undoubtedly the human being must learn to swim, though the dog does not; but then the dog can carry over into the water his running movement, while the human child has to use a movement that he does not use on land. Most skilled movements are learned

combinations of simpler movements that are primarily unlearned.

Yet there is plenty of chance for maturation throughout childhood and youth, to account for the differences between the baby and the young adult. Does the young man's beard appear because of some learning or exercise that is peculiar to boys as distinguished from girls; or does the boy's voice suddenly drop from soprano to bass because of some form of learning in which boys and not girls engage? The increase in muscular strength, also, with increasing age, is not entirely accounted for by exercise. Many other changes that occur, in playfulness, restlessness, learning ability, retentiveness, etc., are likely to be due partly to the mere process of growing up.

One way of experimenting on this question is to attempt to hasten development by extra exercise. For example, let a boy of twelve attempt to develop his muscles, so as to reach the usual sixteen-year-old condition ahead of time. Undoubtedly the exercise would strengthen his muscles, but this result by itself would not be enough. The experiment should continue by having him drop the extra exercise after a year, let us say, and revert to the ordinary amount of exercise of boys of his age, so as to see whether he maintained the lead he had obtained by the extra exercise. If the extra exercise had put him, at the age of thirteen, on a par with the norm for fourteen years, then will he reach the sixteen-year level when he is fifteen? He certainly should, if no maturation is involved in the growth of muscular strength between the years considered. This is just an imaginary experiment, so that no results can be given. But experiments after this model have been tried in regard to intelligence and memory span.

By coaching a child in the Binet tests, or in a form-board test, or in the man-drawing test, you can improve his score, and raise his apparent IQ. Now let him go for six months, and test him again, and you find that he has lost the results of the

coaching, and reverted to his original IQ. Forcing has produced only a temporary acceleration of development.

The memory span for digits increases with age, being about four digits at the age of five, about six digits at the age of ten, and about seven digits at the adult level. Is this increase the result of exercise, or of maturation? A very definite experiment has attacked this question. Kindergarten children, four and five years old, were given daily practice for over four months, and their memory span was thus raised from about 4 digits to about 6 — quite a large gain, in terms of age norms. A control group of kindergarten children, matched child for child with the practice group, in sex, age, mental age, and memory span at the beginning of the experiment, but not given the special practice, made only a slight gain during these four months. Now came the summer vacation, with no further practice in memorizing digits, and after that another test was made, to see whether the practice group still maintained its lead on the control group. But no — both were now on the same level. The following table gives the exact results:

IMMEDIATE AND LATER EFFECTS OF INTENSIVE TRAINING IN MEMORY SPAN (from Gates and Taylor, 1926)

	Practice group	*Control group*
Average score before training	4.36 digits	4.41 digits
Average score at end of training	6.36 "	(5.08 ")
Average score after four months of disuse	4.71 "	4.77 "

You can put the five-year child on the ten-year level in some special performance by intensive training, but he doesn't stay put, unless you keep up the intensive exercise. But a child that has grown up to the ten-year level does not need this intensive exercise to keep him on that level. The results are certainly much easier to explain if we are allowed to assume

a maturation process in addition to development through exercise, than if we are pinned down to exercise alone.

Sex development. Sex maturity in the human species comes after so many years of active learning that it is difficult to say how much of sex interest and behavior is learned and how much unlearned. There can be no doubt about the primary physiological sex processes. Menstruation, appearing in girls at puberty, is certainly not the result of any sort of learning. In some animals that have been studied, sex behavior in courtship and mating is partly unlearned, though it does not make its appearance till long after birth. In that much-studied animal, the white rat, sociable responses to animals of either sex, indifferently, occur long before sex maturity and play a part also in sex behavior, but there are definite responses to the other sex that emerge suddenly at maturity. In the chimpanzee, on the other hand, the development is more gradual, as it probably would be in human beings also, in the absence of all social control. As a matter of fact, attraction towards the opposite sex is felt by a small proportion of children, by most adolescents from 15 to 20 years of age, by a minority not till a few years later, and by a small number never at all. In view of all the opportunity that children have to pick up this interest by imitation of their elders, the usual delay of sex interest is decidedly significant. Give a boy of twelve or fourteen a love story to read, and he finds it insufferably dull and silly, unless it has some adventure mixed in. Even in very different cultures from ours, the same shift from consorting with one's fellows of the same sex, to interest in the other sex, takes place in adolescence. The details of courtship and marriage differ from one culture to another, and are of course learned by the individual.[5]

[5] References: C. P. Stone, *American Journal of Physiology*, 1924, vol. 68, pp. 407–424; H. C. Bingham, *Comparative Psychology Monographs*, 1928, no. 23.

INSTINCT

The term, instinct, is primarily a term for use in animal psychology. Instinct is contrasted with intelligence and reason, with planned and deliberate action, with action that depends on previous learning. Instinct is best defined as unlearned behavior.

Some of the clearest examples of complex instincts are found in the insects. When a mother wasp builds a cell of mud, fills it with food suitable for a young wasp, lays an egg inside the cell, closes the top of the cell with a lid of mud, and then goes about her business, we know that her behavior is instinctive because she has had no possible chance to learn from older wasps. She has never seen a wasp's nest made, for when the last preceding crop of nests was being made she was herself an unhatched egg. Therefore, she cannot possibly know the use of the nest with its egg and store of food. She has no "reason" for building the nest, no ulterior purpose, but is impelled to build the nest, simply and solely for the sake of doing just that thing. Thus instinct is contrasted with calculated or reasoned action as well as with learned action. Calculated action is based on knowledge of cause and effect, and this knowledge is acquired by the individual in the course of his experience; but instinct is not based on the individual's experience, but only on his native constitution and maturation.

A typical instinct, such as this one of the wasp, consists of a fixed sequence of activities, here cell-building, filling with food, laying the egg, closing the cell. The completion of each activity sets the next one off. If you try a little experiment on her, by cutting away a part of the mud wall while she is out gathering her store of food, she examines the injury carefully on her return, but keeps right on gathering food till the cell is filled, after which, going on to her final masonry job, she brings mud and closes the whole cell up. She cannot be de-

flected from her fixed sequence, even if the repairs are very necessary.

The spider's web is a beautiful specimen of instinctive construction. The spider proceeds in a fixed order. It spins first an outer framework, then the radii between this rim and a central point, then a few cross strands tying the radii together and stiffening the whole, and finally it proceeds to the main job of spinning the close parallel circular threads. If an experimenter breaks some of the cross strands, the spider doesn't go back and replace them, but keeps on spinning though the web now becomes slack and mussy. Apparently the spider cannot deviate from its fixed sequence. Instinct can thus be made to appear very stupid, when conditions are made abnormal. Still, the instinctive performance is not completely blind and unvarying. It adapts itself to the surroundings. In ants and bees, there is so much adjustment to conditions that one doubts whether their whole behavior is instinctive, and whether some learning does not enter.[6]

The nest building of birds must be largely instinctive, since only one nest a year is built, and the yearlings, when they come to build, have no past experience to guide them. Birds also have very definite " habits " of courtship, that are probably unlearned. Mammals, in general, show less than birds in the way of fixed, elaborate action patterns that can be identified as instincts, and this is specially true of the higher animals. Still, such reactions as the barking of dogs and the special hunting behavior of setters and pointers are certainly unlearned.

When we come to man, learning plays so large a part in his development that few action patterns can be found conforming to the typical instincts as seen in insects. It is doubtful whether it is worth while to use the term, instinct, at all in human psychology. The term has been used by many psycholo-

[6] R. W. G. Hingston, *Problems of Instinct and Intelligence*, 1928.

gists, with the laudable object of emphasizing the fact that human behavior, though so fluid and dependent on learning, starts in each individual with unlearned behavior. All learned activities develop out of unlearned. Conditioned reflexes develop out of unconditioned. Skilled movements are combinations and specializations of unlearned movements. Seeing an object to know it develops out of just seeing it as the infant does without previous learning. In general, learning consists in modifying an activity, and the unmodified activity must have occurred before the learning. The adjective, instinctive, would often be a convenient substitute for "unlearned," and the adverb, instinctively, a convenient substitute for the phrase, "without previous learning." But when the noun, instinct, is used, we assume it to refer to some definite action pattern that is wholly unlearned, and such patterns scarcely exist in human behavior, beyond the fairly simple and momentary responses that we can just as well call reflexes — such responses as breathing, swallowing, coughing and sneezing. It is scarcely worth while to retain the term, instinct, just for this type of responses.

If we use the word, instinct, in speaking of human activities, we immediately become involved in controversies which are mainly disputes over words. We probably contrast instinct with habit, using the former for an unlearned activity, and the latter for a learned activity. But then, since every activity is partly unlearned and partly learned, we can draw no sharp line between instinct and habit, and are always quarreling over the proper name for a given activity, though there is no real question as to the facts. If we call eating an instinct, some one objects that we are overlooking all the learning that occurs in ways of preparing food and putting it into the mouth, and all the social customs that have grown up around eating. But if we call eating a habit, we are accused of taking the absurd position that man eats only by force of habit and not because

he is hungry and has the unlearned mechanism for satisfying this organic need. If we speak of the sex instinct, some one is sure to carry away the impression that romance, courtship and marriage, as practiced among men, are unlearned activities on a par with the nest-building of wasps; but if we speak of sex behavior as a habit, we convey the impression that the attraction of one sex for the other is a mere matter of social convention. On the whole, we shall save trouble by minimizing the use of both terms, instinct and habit, and leaving both to be terms of popular rather than of scientific use.

The main interest in the question of instinct, in human psychology, arises when we come to study motivation. An instinct may be thought of as a basic motive to action, even when the action itself is learned. Hunger itself is certainly not learned; and the adult who eats when hungry is driven by an instinctive need, no matter how well-trained he is in his choice of foods and in his table manners. So the thirsty individual may be said to be following instinct, no matter exactly how he has learned to drink. Whether this is the best way to state the facts will be a question for our later discussion of motivation.

EXERCISES

1. Fill in the blanks in the following paragraphs, so making a brief outline of the chapter:

A. The individual's ...., in which psychology is interested, depends upon his structure, and this upon his ...., which in turn depends upon both .... and ....

B. The individual's heredity is at first contained in the two ...., the union of which constitutes the new individual, and is transmitted to every one of the .... cells, of which the developed .... is composed.

C. If the environment of two individuals is identical dur-

ing development, but their heredity different, the individuals develop ...., as shown by the case of ....

D. If individuals of identical heredity develop under radically different environmental ...., they develop ...., as shown by the case of ....

E. Though we cannot say that some behavior is due to .... alone, and other behavior to .... alone, we can say that some differences between .... are due to the one and some to the other.

F. As to sex differences, some, such as those in .... strength or in age of ...., are probably due to heredity, while the preferred ...., though not .... upon the man or woman by heredity, are not .... due to environment either, but are .... of the two forces. Mental tests show only .... differences with much .... between the sexes.

G. Conformity to type cannot be due either to heredity or environment, but to .... Yet it is true that both heredity and environment exert some .... influence on the individual.

H. Maturation and learning are two types of ...., both dependent upon .... stimulation, but to get learning the stimulation must arouse ...., and so .... the organs concerned. All learned activities develop as .... of unlearned.

I. Maturation is responsible for most of the development that takes place .... birth, and, since a developed structure is ready to ...., the activities that appear at .... are mostly .... Birth occurs at different .... of .... in different animals, and undoubtedly some .... occurs after birth, and on even to .... The development of sex behavior during adolescence is therefore not entirely due to .... influence.

J. Instinct is best defined as .... behavior, and best illustrated in .... As all complex human

behavior shows the .... of both ....
and ...., the distinction between instincts and
.... cannot be applied here in a concrete way.

2. The scientific and practical value of making a psychological study of foster children.

3. Debate the question whether it is more scientific to assume race or sex differences to be environmental, than to assume them to be hereditary.

4. Show how sleep acts as a regularizing factor, akin to forgetting, and also how ideals operate as social regularizing factors.

5. From your knowledge of family life, discuss the statement that the same home is not the same environment to all the children in it.

6. Suppose you started reading the chapter with the idea that some forms of behavior were native and due to heredity, and others due to environment — what does the chapter allow you to keep that is in line with your first idea?

7. What is meant by the word "instinctively" in such common phrases as, "seeing a big dog bounding towards me, I instinctively put my hands in my pockets," or, "in the presence of such grief, I instinctively removed my hat"?

8. Discuss this statement: "The child is born with muscles every one of which can act singly, but all the combinations of these separate muscular actions are learned."

9. Devise an experiment to test whether dogs have an unlearned dislike of cats.

10. Of recent years, there has been much objection in psychological circles to the speaking of any human instincts, and an inclination to speak of all human behavior as consisting of habits. Why not?

REFERENCES

Among numerous important works in biology, on genetics and development, reference may be made to W. E. Castle, *Genetics and Eugenics,* 1923; and to C. M. Child, *Physiological Foundations of Behavior*, 1924.

For discussions of Instinct, see E. L. Thorndike, *The Original Nature of Man,* 1913; and W. McDougall, *Introduction to Social Psychology,* 12th ed., 1917, pp. 19–120, 385–424. These treatments

antedated the recent heated discussion on the question of human instincts, in which prominent parts have been taken by L. L. Bernard, *Instinct, a Study in Social Psychology*, 1924; and by J. B. Watson, *Behaviorism*, 1924, pp. 74-107. A review of the whole discussion is given by G. Murphy, *An Historical Introduction to Modern Psychology*, 1929, 336-346.

CHAPTER VI

HOW ACTIVITY IS AROUSED: THE STIMULUS AND THE MOTIVE

FACTORS BOTH WITHIN AND WITHOUT THE INDIVIDUAL THAT DETERMINE WHAT HE SHALL DO AT ANY MOMENT

Let us suppose we have before us for study a typical human individual, and we wish to ascertain what he can do. We would like to find out everything he can do. We are not satisfied to be told; we insist on witnessing all the activities of which he is capable. How shall we proceed? In two words, the answer is: apply the right stimuli, and motivate your individual. Probably he can sneeze, but not unless he gets the right stimulus. Probably he can count to ten thousand, but he is not likely to do so unless you can appeal to some strong motive or interest.

Stimulus and response. A stimulus is any form of energy acting upon a sense organ and arousing some activity of the organism. The stimulus may be pressure on the skin, light entering the eye, sound entering the ear, etc. Usually the stimulus is complex. Much light, of different shades and colors, is entering the eye from the objects before it. The whole mass of stimuli acting at once upon the organism may be called the situation. Sometimes, but not always, it is possible to specify which stimulus out of this whole mass is effective in arousing an activity. If a person starts at an unexpected noise, the noise rather than any other element in the situation was the effective stimulus.

A response is any activity of the organism that is aroused by a given stimulus. On the assumption that any activity that

occurs is touched off by some stimulus, a little scheme or formula for the arousing of activity is often employed, namely, the stimulus-response formula, written

$$S - R, \text{ or } S \rightarrow R,$$

in which S stands for the stimulus, and R for the response, so that the formula reads, "A stimulus arouses a response," or, more significantly, "The response is aroused by a stimulus."

Sometimes this formula is interpreted to mean that if you know the stimulus, you can predict what the response will be; or that if you wish to secure a given response, all you have to do is to apply the proper stimulus.

But a little reflection shows that the formula, so interpreted, is incomplete; for the stimulus really acts upon the organism, and the organism makes the response. If we use the letter O for the organism or individual, our formula should properly read,

$$S - O - R, \text{ or } S \rightarrow O \rightarrow R,$$

and be read that the stimulus, acting upon the organism, elicits a response, or that the organism makes a response when it is aroused by a stimulus. In order to predict the response, we must know not only the stimulus, but also the organism stimulated.

If you hear some creature stirring in a hedge, and "coo" to it, it will probably fly away if it is a bird, and rush toward you if it is a dog. If it is a human being, it would be hard to predict the response, without knowing the age, sex, and training of the individual, and the mood he or she happened to be in at the moment. You must know your O.

You must know the stock of activities which O possesses, by virtue of maturation and previous learning. You must know the present state of O, whether awake or asleep, hungry or satiated, happy or sad, calm or excited. And you must

know what O is doing at the moment, what activity your stimulus is breaking in upon. If he is lost in thought, he will not notice your "coo" at all, but if he is trying to do something in which he needs help, he will respond eagerly. These three things you must know about the individual stimulated, in order to predict his response: his equipment or repertory of possible responses, his present organic state, and the activity in which he is engaged.

The stimulus, then, is not the cause of the response — not the full and sufficient cause. The stimulus does not exactly produce the response, but it arouses or releases the response, as the blow of the trigger releases the charge in a gun. The energy of the response may be much greater than that of the stimulus, as we see when a light touch on the skin of an unsuspecting person arouses a violent muscular start. The energy of the response is not derived from the stimulus, but from food and oxygen previously taken in by the organism. The organism always has a store of potential energy, and the stimulus releases some of this energy.

Not only the energy, but the form or character of the response depend on the organism. The character of a muscular response depends on the muscles and their attachment to the bones and on the nerves controlling the muscles. Different organisms, being differently organized, respond differently to the same stimulus, and even the same organism responds differently at different times, because of changes in its internal condition. In general, then, the response depends on the structure and condition of the organism. But of course it depends on the stimulus as well.

Motivation. "Motive" is not a technical term in psychology, but it seems to correspond rather closely with what we have just called "activity in progress." However, it may be used a little more broadly to include organic states as well. So, we can speak of hunger as a motive. A motive is present in

O before a given S arrives, and helps determine what R shall be made. A motive favors certain responses, and disposes the organism to react to stimuli that arouse these responses. So, hunger favors eating movements, and disposes O to respond to eatables.

If my hand touches a hot stove and I jerk it away, there is no excuse for saying that my motive was to remove the hand from the hot object. The movement is a direct response to the stimulus, and there was no motive present in advance preparing me to make this response. But suppose, the pain in my hand continuing, I catch sight of a pail of water and plunge my hand into it. Since this is not the usual and dependable response to a pail of water, a psychological observer would have good reason for asking why I did it; and the answer would be that I was seeking to escape from the pain, and responded to the pail of water accordingly. At that particular moment, the sight of the pail of water is the stimulus, but there is something more in the game and controlling the response to this stimulus; there is, namely, an activity in progress, a seeking to escape from the burning pain in my hand. A motive, then, is an activity in progress, or an organic state already present when a given stimulus arrives; and the motive plays a part in determining what response shall be made to the stimulus.

If a motive is an organic state, or activity in progress, *motivation* is the producing of such a state or activity. It might seem that the concept of motive would be distasteful to the behaviorists and animal psychologists, but such is not the case. In any experiment on animal learning, the experimenter must motivate the animal in order to get action. Pavlov had to use *hungry* dogs in order to establish the conditioned salivary responses. Trial and error behavior depends on motivation. A green experimenter placed a well-fed cat in a cage, with plenty of bars, bolts and strings provided as stimuli for the cat

to respond to; but what the cat did was to curl up and go to sleep. Hunger is the motive or "drive" most used in animal experiments, but others sometimes used are the sex drive and the drive to escape from confinement (what Pavlov calls the "reflex of freedom"). A mother animal separated from her young is strongly motivated to get back to them. A chick separated from the mother hen and brood runs about, cheeping, till it regains the brood. Some of these motives employed in behavior studies are evidently organic states or "needs," while others fit better under the head of activities in progress. Since an organic state can be regarded, with a little straining, as an activity, the general rule for successful motivation is to get an activity started that will favor the responses you wish to elicit.

The importance of motivation is seen, at a much higher level of behavior, in college work. The colleges take great pains to select freshmen who promise to do well in academic work. By intelligence tests and achievement tests, they obtain pretty good indications of the abilities of the students. But the actual performance of the students in curricular work corresponds only moderately with their indicated abilities, or, probably, with their real abilities; for some of less ability are strongly motivated, and some of greater ability are only weakly motivated towards their studies. Such a case history as the following is not unusual.

A boy enters college with a good high school record, and a reputation from his previous teachers of being bright but not over-studious. In the freshman intelligence tests he makes a high score. His college work immediately strikes a moderate level, quite in harmony with that of the group of students he joins. There are a few high spots and more numerous low ones in his record. In sophomore year he is placed on probation for poor scholarship, and then advised to go to work for a year. After a year in business, he returns to college and

resumes his old level, which he maintains for two years. Finally, in his senior year, an attractive job appears on the horizon, demanding, however, certain lines of knowledge which he does not have. He wakes up and does intensive and successful work in the courses that will equip him for this position. What this young man lacked, all through, was motivation rather than ability. His general activity level, extra-curricular as well as curricular, was low or moderate at the best, and such energy as he put out was diffused rather than concentrated. A motive releases energy, and helps determine the direction that the energy shall take.

To predict what an individual is going to do in life, you need to know both his abilities and his motivation. To predict what he will do in a given situation, you need to know what responses he has available, his organic state at the time, and the activity that he has in progress.

We have been proceeding rather hastily, in order to get a first glimpse of this large problem of how to secure action. Now let us explore the ground more minutely. There are several kinds of activity to consider: reflex action, prepared action, purposive action. If motivation is so important, we should ask what are the big dependable motives of life, and how they work together and conflict with each other.

REFLEX ACTION

A reflex is an unlearned activity which is so closely attached to some stimulus as to be fairly dependable. You have only to apply the stimulus and you elicit the response. In a true reflex, both the motor (or glandular) activity and its connection with the stimulus are unlearned. In a conditioned reflex, the motor or glandular activity is unlearned, but its attachment to the conditioned stimulus has been established by a process of learning or exercise.

The knee jerk, or patellar reflex, is a sudden, brief contrac-

tion of the big thigh muscle that straightens the knee, and the only stimulus that can arouse just this response is a sudden stretching of that muscle, as by a blow on the patellar tendon just below the knee. The knee jerk is very exceptional in that it can be aroused by only one stimulus. The pupillary reflex — narrowing the pupil of the eye — can be aroused in at least two ways, by bright light and by looking at a very near object; and the widening of the pupil can be aroused in at least three ways, by dim light, by looking off at the distance, and by a sudden noise or touch on the skin. The eyelid reflex, or wink reflex, is aroused by an object getting into the eye, and also by an object approaching the eye. The flexion reflex of the arm, or hand withdrawal reflex, can be obtained by a burn or prick or tickle anywhere on the hand or forearm.

Let us apply the stimulus-response formula to the case of the reflex. If anywhere, the simpler form, S — R, should be sufficient here. In the true reflex, R is strongly and permanently attached to S. Yet it would be misleading to speak of the S — R as an indivisible unit, for the same R may have attachments to several stimuli, as we have just seen. When an R becomes conditioned, it becomes attached to a new S. Instead of thinking of S — R as a unit, we have to think of the R as the unit, a unit of activity which may be aroused by several different stimuli, in most cases.

But the organism, O, has to be considered even here. Though the reflex is a *fairly* dependable response to the stimulus, it fails in certain conditions of the organism. If O is in a condition of terror, with pupils widely dilated, bright light entering the eye fails to give the pupillary reflex. If O is anxious about his knee jerk, the blow on the tendon fails to elicit the reflex. But if O clenches his fist a second before the patellar tendon is struck, the reflex will be unusually strong. If O is carrying a hot dish which he dares not drop, the heat on his hand does not arouse the usual flexion reflex. So we see that, even in

the case of reflexes, we cannot predict the response from knowing simply the stimulus, but must know also the condition of the organism.

Facilitation and inhibition. Any influence that helps a response to occur is said to facilitate it, and any influence that hinders it from occurring is said to inhibit it. Facilitation and inhibition are illustrated by the instances just cited. The knee jerk is facilitated by clenching the fist, and also by a loud noise coming a second before the blow on the tendon. Sneezing may be inhibited by pressure on the upper lip and nose. Usually there are several or many stimuli acting upon O, and they are likely to get together, not each producing its own reflex as if the others were not present, but facilitating or inhibiting each other's effects.

Reflexes are interlocking mechanisms, some facilitating each other, and others inhibiting each other. Flexion and extension of the same limb are interlocked (in the nerve centers) in such a way as to inhibit each other. The two hind legs are so interlocked in the nerve centers that reflex flexion of the one inhibits flexion of the other, but facilitates extension of the other. If you pinch one hind paw of a dog, that paw will be drawn up, and the other hind leg stiffened. If you pinch both hind paws at once, you do not ordinarily get both legs drawn up at once, but only one. Similarly, if you tickle a dog's right flank, the reflex response is scratching by the hind paw on the same side, with stiffening of the opposite hind leg which thus supports the body. If you tickle both flanks at once, you do not get scratching by both hind paws at once, but only by one, with a *shift* a little later to the other. In the same way, once more, if you suddenly show an object off to O's right, his eyes probably turn towards it; and the same if you show an object off to his left. But if you show both at once, one eye doesn't look to the right and the other to the left, nor do both stare straight ahead — no compromise of any sort. Both eyes turn

to one object, and a little later, probably, shift to the other. So we see that the reflexes form a well organized system.

We see, more in detail, four **laws of reaction** that appear again later in attention and sense-perception. These are:

(1) The law of *selection:* of two or more inconsistent responses to the same situation (or complex of stimuli) only one is made at the same time. One gets the right of way, and the others are inhibited for the moment at least.

(2) The law of *advantage,* or of prepotency as it is sometimes called: one of the inconsistent responses has an advantage over the others, and is more dependable than the others.

(3) The law of *shifting:* the response that has the initial advantage loses its advantage shortly, and an alternative response gets the right of way, provided the situation remains the same.

(4) The law of *combination:* response is usually made, not to each separate stimulus separately, but to combinations of stimuli; several stimuli arouse a joint response.

The law of advantage deserves a little further illustration. There are many different factors of advantage. For example, the strongest stimulus is apt to prevail over the rest, and secure the right of way for its own special reflex. But some responses have an inherent advantage over others. Protective reflexes prevail over all others, and postural reflexes yield to all others. Suppose, for example, that a dog is standing, a postural reflex being thus in action, and that you simultaneously pinch his paw and tickle his flank. Three demands are simultaneously made upon O: to stand on that foot, to scratch with it, and to pull it away. The flexion reflex, the most protective of these three, gets the right of way, but the scratch reflex has the next best chance.[1]

[1] C. S. Sherrington, *The Integrative Action of the Nervous System,* 1906.

PREPARED ACTION

A reflex does not have to be put into a condition of readiness before its stimulus is applied. It is always ready, aside from interferences that may be present. The same is true of some conditioned fears and avoiding responses. And it is just as true of the recall of well-learned facts, and of the recognition of familiar objects. The response in such cases is so well tied to the stimulus that no preparatory tuning up is necessary. But there are many sorts of activity that do not occur unless the individual is prepared.

The reaction time experiment. A simple type of experiment, employed with numerous variations in the laboratory and in testing, is the measurement of reaction time. The object is to see how long it takes O to respond to a stimulus, or how much time elapses between S and R. The experimenter tells his subject to be ready to make a certain movement as promptly as possible on receiving a certain stimulus. The response prescribed is usually a movement of the forefinger, and the stimulus may be a sound, a flash of light, a touch on the skin. The subject knows in advance exactly what stimulus is to be given and what response he has to make, and is given a "Ready!" signal a few seconds before the stimulus. With so simple a performance, the reaction time is very short, and delicate apparatus must be employed to measure it. The chronoscope or clock used to measure the reaction time reads to the hundredth or thousandth of a second, and the time is found to be about .15 sec. in responding to sound or touch, about .18 sec. in responding to light.

Even the simple reaction time varies, however, from one individual to another, and from one trial to another. Some persons can never bring their record much below the figures stated, while a few can get the time down to .10 sec., which is about the limit of human ability. Every one is bound to vary

from trial to trial, by a few hundredths of a second at the least. It is curious to find the elementary fact of variability of reaction present in such a simple performance.

What we have been describing is known as the "simple reaction," in distinction from other experiments that demand more of the subject. In the "choice reaction," there are two stimuli and the subject may be required to react to the one with the right hand and to the other with the left; for example, if a red light appears he must respond with the right hand, but if a green light appears, with the left. Here he cannot allow himself to become keyed up to as high a pitch as in the simple reaction, for if he does he will make many false reactions. Therefore, the choice reaction time is longer than the simple reaction time — about a tenth of a second longer.

The "associative reaction" time is longer still. Here the subject must name any color that is shown, or read any letter that is shown, or respond to the sight of any number by calling out the next larger number, or respond to any suitable word by naming its opposite, etc. He cannot be so well prepared as for the simple or choice reaction, and his reaction time is about a tenth of a second longer, at the best, than the choice reaction. It may run up to two or three seconds, even in fairly simple cases, while if any serious thinking or choosing has to be done, it runs into many seconds and even into minutes.

These laboratory experiments can be paralleled by many everyday performances. The runner starting at the pistol shot, after the preparatory "Ready! Set!", and the motorman applying the brakes at the expected sound of the bell, are making "simple" reactions. The boxer, dodging to the right or the left according to the blow aimed at him by his adversary, is making choice reactions, and this type is very common in all kinds of steering, handling tools and managing machinery. Reading words, adding numbers, and a large share of simple

mental performances, are essentially associative reactions. In most cases from ordinary life, the *preparation* is less complete than in the laboratory experiments, and the reaction time is accordingly longer.

The simple reaction has some obvious resemblance to the reflex. It is never as quick as the quickest reflexes, such as the eyelid reflex, which gets started in .05 second, or the knee jerk, which takes only .03 second to start. These, however, are about the quickest of all reflexes, and some others are no quicker than the simple reaction.

The simple reaction is obviously an S — R affair, much like the reflex. But the linkage between S and R is only temporary in the simple reaction. The subject in a reaction time experiment would not make that finger move in response to that stimulus unless he had made ready to do so. In order to predict the R from the S, we should need to know that O was prepared to do just this thing. The simple reaction typifies a host of activities that are not specially attached to any stimulus, but which the individual can temporarily attach to a certain stimulus by suitable preparation.

The preparatory set or adjustment. The runner on the mark, " set " for a quick start, is a perfect picture of preparedness. Here the onlookers can see the preparation, since the ready signal has aroused visible muscular response in the shape of a crouching position. It is not simple crouching, but "crouching to spring." But if the onlookers imagine themselves to be seeing the *whole* preparation — if they suppose the preparation to be simply an affair of the muscles — they overlook the established fact that the muscles are held in action by the nerve centers, and would relax instantly if the nerve centers should stop acting. The preparation is neural more than muscular. The neural apparatus is set to respond to the pistol shot by strong discharge into the leg muscles.

The preparatory set for an act consists in going as far as

possible towards the execution of the act, without actually releasing it. In a false start, or premature reaction, such as often occurs on the running track, preparation has gone a little too far, and released the reaction before the stimulus has arrived.

To adapt our S — O — R formula to prepared reactions, we have to remember that there are two reactions in series here. First, the preliminary signal, P, arouses a readiness to make a certain response; and then comes the stimulus, S, and releases that response. Since the preparation consists in making a start towards R, we may let little r stand for this preparation or set. Then we have

1. Preparation: P — O-r
2. Execution: S — (O-r) — R

The compound symbol, (O-r), denotes O in the state of readiness to make R. S finds O in this prepared state, with the activity R already in progress, but suspended, and gives O the necessary nudge to release the complete R. The symbol (O-r) may also be read, "O set for the response R."

The delayed reaction experiment, cited once before in our study of animal learning, can be used here as another illustration of preparation for action. The animal in that experiment gets a signal indicating where he is to find food, but is not free to go there at once. If the delay is not too long, he will go to the right place when he is freed. To keep his bearings during the delay, the rat must maintain a motor set, but the monkey can move around during the interval of delay and still maintain a brain set that prepares him for the right response.

Preparatory reactions. In the experiments just cited, on delayed reaction in animals and on reaction time in men, there is nothing for O to do during the preparatory period except to get ready and wait. But in many other cases there is much

varied activity between the preliminary signal and the final response.

You whistle for your dog when he is some distance off and out of sight. You give one loud whistle and wait. Presently the dog swings around the corner and dashes up to you. What kept him running towards you after your whistle had ceased? Evidently the whistle gave him a set, similar to the set in the delayed reaction experiment, except that here there was no empty waiting. He made many preparatory reactions on the way to his final reaction of jumping up on you; and these preparatory reactions were, of course, responses to the trees he had to dodge and the ditches he had to jump; but they were at the same time responses to your whistle, or to the set left behind by your whistle. The set facilitated responses that led towards you and inhibited responses leading elsewhere.

The daily activities of life are better represented by the dog coming at the sound of the whistle than by the simple reaction or the reflex. Behavior usually comes in lengths, not in separate reactions. You put on your coat and hat; you go out to the garage; you start the car; you back out; you take on your passengers; you drive them to the station. Thus one might list the acts performed in a certain quarter of an hour. Each of these acts includes a series of smaller acts leading up to some end result. When you start upon each series, you are starting towards the end-result of that series. You are set for that end-result. You have embarked upon a certain total activity, which immediately becomes your "activity in progress," and motivates all the detailed movements or preparatory reactions composing the total activity. What you are doing in toto determines what you do piecemeal. If any one asks you why you are doing this (detail), your answer is, "Because I am doing that (total act)." "Why are you turning the knob?" "Because I'm opening the door." "Why are you opening the

door?" "Because I'm going to the garage." "Why are you going to the garage?" "Because I'm taking some people to the station." "And why do that?" "I'm helping them get to their business on time." And so on. Each smaller act finds its motive in the more inclusive activity in progress.

In short, there is nothing mysterious about motives. They are not forces or stores of energy in any absolute sense. They are simply activities that have got started but not yet finished. The significant fact is that activity does occur in large action patterns, more than in single reactions.

The relation of motive and stimulus is well illustrated in feeding activity. Hunger is the motive here, food within reach is the stimulus. Neither alone is enough to arouse actual eating movements. The hungry individual does not start chewing till the food is actually there. On the other hand, the presence of food does not arouse eating unless the individual is hungry. Try to get a baby to take more from his bottle than he wants! Eating only occurs when one is both hungry and in the presence of food. Hunger facilitates the eating response to a food stimulus.

The hunger motive does not arouse eating movements while the stimulus of present food is lacking; but, for all that, hunger does arouse immediate action. It arouses the preparatory reactions of seeking food. Any such reaction is at the same time a response to some actually present stimulus. Just as the dog coming at your whistle was responding at every instant to some particular object — leaping ditches, dodging trees — so the dog aroused to activity by the pangs of hunger begins at once to respond to present objects. He does not start to eat them, because they are not the kind of stimuli that arouse the eating response, but he responds by poking them or nosing them or avoiding them. These are preparatory reactions, which, if successful, bring the dog into the presence of food. That is to say, preparatory reactions so change the environ-

ment as to provide the stimulus necessary to arouse the end-reaction.

Our formula for the preparatory set, with a little complication, will cover the case of preparatory reactions. There are several steps in the process. First a stimulus P, such as the hunger pangs, arouses a set towards a final reaction R. This set facilitates responses leading towards the final reaction, and inhibits others. As O encounters various stimuli, S_1, S_2, S_3, etc., he makes responses R_1, R_2, R_3, etc., determined by these stimuli and by the set towards eating, till finally some of these preparatory responses bring him into the presence of the food stimulus S, which arouses the eating response, R. The formula then is:

1. P — O-r
2. S_1 — (O-r) — R_1
3. S_2 — (O-r) — R_2
4. S_3 — (O-r) — R_3
5. S — (O-r) — R

The same formula, by the way, will apply to the trial and error behavior of the cat in the cage, or of the rat in the maze. The long series of preparatory, or trial reactions, made in the first experience with the cage or maze, is short-circuited in the learning process. Many of the stimuli which at first aroused responses come to be disregarded, till finally there may remain only:

1. P — O-r
2. S — (O-r) — R

PLAYFUL ACTIVITY

It is characteristic of young animals to be playful, and this is especially true of the human child. Play decreases as age advances, though man, more than animals, keeps up his playfulness to some extent, and so gets more joy out of life, as

well as prolonging his plastic period; for playful activity, just because it is unorganized and unstandardized, affords a chance for new action patterns to emerge. Play is important for invention, as we shall see later under the head of imagination.

The new-born baby sleeps most of the time, and does not appear exactly playful while awake; but soon he becomes very active with his arms and legs, mouth and vocal organs, and with his eyes as well. Such activity appears "random," that is to say, unstimulated and unmotivated. To adult eyes, it appears to lead to no result of any consequence, except that the exercise is good for the child's muscles and brain; but to the baby it is no doubt satisfying on its own account. The movements, taken singly, are good, well-coördinated flexions and extensions of the limbs, but they produce no definite change in external objects, and so appear meaningless to adult eyes. It is impossible to specify the stimulus for most of these movements; they appear spontaneous, though we must remember that there are plenty of stimuli acting on the child's eyes, ears, skin and muscle sense. Probably the motor machinery is so ready for action in a lively baby that almost any stimulus is enough to set it off.

Manipulation and exploration in play. More and more, external objects are drawn into the baby's playful activity. He turns things about, pulls and pushes them, drops them, throws them, pounds with them, puts them in his mouth. As fast as he learns to manage them, he does more and more complicated things with them. Of course he watches the results of his manipulation. Hands and eyes work together. A blind child is comparatively inactive with his hands, because he doesn't see what happens. So we are not to think of playful manipulation as a purely motor affair; rather, it is motor activity producing interesting external results that can be watched or heard, or sensed in some way.

Exploration is a playful activity that goes right along with manipulation, though it begins earlier than anything we can properly call manipulation. Listening to a sudden noise is one of the earliest exploratory reactions. Following a moving light with the eyes, fixing the eyes upon a bright spot, and exploring an object by looking it all over, are forms of exploration that appear in the first few months of the baby's life. Exploration by feeling with the hands and with the mouth are very early forms. Sniffing an odor is a similar exploratory response. When the child is able to walk, he explores on foot, approaching whatever arouses his curiosity, and when he has learned to talk, he explores by asking questions.

The stimulus that arouses exploratory behavior is something novel or relatively so. When an object has been thoroughly examined, it is dropped for something else.

Manipulation and exploration go hand in hand in the child's play. He likes to get hold of any object that arouses his curiosity. He cannot properly get acquainted with the object by simply looking at it, but needs to make it perform; and there would be no point in manipulating an object unless he could observe how the object behaved. By playing with objects, the child becomes acquainted with the world and learns to take a hand in the processes that go on in the world. His action patterns become more and more tied up with objects, less and less merely motor affairs, more and more a managing of objects and watching the objective results. The baby becomes more and more objective and observant.

PURPOSIVE ACTIVITY

Up to this point we have avoided the word, "purpose" in favor of non-committal terms like "set," "adjustment" and "preparation." These latter terms do not imply any foresight or anticipation of the result of an activity. Though the word "purpose" is sometimes used so broadly as to cover any

activity directed to a definite end, it is better reserved for cases where the end is anticipated by the individual acting. The anticipation may be more or less definite, more or less conscious, but unless there is some *conscious anticipation* of the result we should hardly speak of purpose.

Whether the dog coming at the sound of the whistle anticipates the end result of his activity, it would be difficult or impossible to prove. What we do know is that the whistle started something going in the dog that did not run down till the end result was reached. So we say that the whistle set him, or adjusted him, for this total activity with its end result. But when the individual is not only set for a certain activity, but also foresees the outcome of the activity, then the activity is purposive. A purpose is a set for a certain activity with foresight of the result of that activity.

A reflex is not purposive, however useful it may be. The stimulus simply arouses the response, with no preliminary set or motivation. At least this is true of the simpler, prompter reflexes, such as the eyelid or the flexion reflex. Sneezing and coughing often hang fire, the stimulus being not quite strong enough to release them, and yet strong enough to produce an irritating sensation and a desire to sneeze or cough. We may, very definitely, anticipate a sneeze before it comes off; also, we may be entirely set for it; and we can then call it purposive. The purpose here is simply to sneeze, and this purpose may lead us to help the sneeze along by little tricks we have learned. Or, quite as often, the sneeze-stimulus may break in on an activity in progress, and the purpose aroused may be that of suppressing the sneeze by use of other little tricks we have learned. There are several other reflexes, such as swallowing, breathing, and the evacuation of wastes, that come under the individual's control, by a process of learning, and are thenceforth checked or let go purposely.

Conditioned reflexes are usually assumed to occur about as

automatically as true reflexes, and without any anticipation; but the assumption can scarcely be proved or disproved. Whether Pavlov's dogs anticipated the food which regularly followed the bell, who can say? They acted as if they did; that is, they not only secreted saliva but turned towards the usual source of food. But the case for anticipation is no clearer, certainly, than with the dog coming in response to the whistle. The set in the delayed reaction experiment, again, need not have been a definite anticipation. Even the monkey that was shown to be set not only for the location of the food, but for banana rather than lettuce to be found there, may not have had a conscious anticipation. The animal psychologists, not being able to get any introspective report from the monkey, avoid speaking of anticipation or purpose, and speak instead of a set or adjustment of the organism.

Just at this point, some confusion of thought is likely to creep in. If we can get along without the notion of conscious purpose in animal psychology, why not in human psychology? If behavior so complex as that of the monkey just mentioned is to be explained in non-committal terms like set and adjustment, why not stick to them when we come to human behavior? How can a conscious purpose have any effect on the brain and muscles, anyway? Thus one of the old puzzles of philosophy is injected into our peaceful psychological study, muddling our heads and threatening to wreck our intellectual honesty. We cannot deal with this metaphysical question here. But we can object to any one who would frighten us away from the facts of human purpose, for fear they would disturb some neat philosophical system.

Special characteristics of purposive activity. (1) Precision of adjustment. Conscious purpose, as we know it from human testimony, is often extremely precise. Your friend starts up and says, "I'm going over to the book store to get a little pocket

memorandum book," and you know that he is set to do just that thing. A large share of human behavior is directed to precise ends, often formulated beforehand in words, sometimes in mental images, sometimes in drawings, designs, patterns, and models, of various kinds. Such precise adjustments of the organism are not known to occur except as conscious purposes.

(2) Novelty of adjustment. An activity that has been repeated many times in the same way becomes pretty automatic. An adjustment that has been set up repeatedly may be very effective while nearly unconscious. But when a new action pattern must be organized, anticipation comes in very keenly. A simple instance is afforded by the reaction time experiment, already described. A beginner in this experiment anticipates the stimulus to which he is to respond, or the movement that he is to make, or both, as vividly as possible. That is his way of getting up an effective set. As the experiment proceeds, and he becomes accustomed to the task, his anticipation reduces to a general feeling of readiness. Purposive behavior is new behavior, rather than habitual behavior. It is behavior in the making, rather than behavior already organized.

(3) Intensity of adjustment. As long as a well-practiced action pattern operates smoothly, and always gives the expected result, the expectation may consist in little more than a general feeling that all is well. But if the act meets a snag or runs off the track to give an undesired result, then the individual rouses his energies and highly resolves to do the thing right. Thus he tunes up his adjustment.

(4) Breadth of adjustment. A complex act or series of movements is likely to be purposive as a whole, and directed towards an anticipated result, while the single movements that make up the total act are mechanical, their particular results being no longer thought of separately. The expert typist writes the letters, and even the words, quite mechanically, but

all the time is consciously aiming to write a certain sentence. In the same way, in signing your name you have no conscious intention to write each successive letter, but you fully intend to write your name. The higher unit is purposively undertaken, while the component parts run off automatically.

Purpose, according to all that has been said, need not be thought of as something lying outside of the general scheme of stimulus and response that we have been following. Conscious purpose is an adjustment still in the making or just being tuned up, and specially an adjustment that is broad and still precise. Purpose is not something foreign to an activity and directing it from outside, or from above. Purpose is the activity itself, initiated but not completed. It is an activity in progress. No doubt you can think of doing a thing without really starting to do it; but if you fully decide to do this thing, you immediately start preparatory reactions or at least establish a preparatory set for the whole activity.

CERTAIN DEPENDABLE MOTIVES — OFTEN CALLED INSTINCTS

We agreed to give up the word *instinct* for such activities as feeding and mating and escape from danger, because these activities in man are largely learned. At the same time, we declined to call them habits, because they are largely unlearned. Each has a nucleus that is unlearned, but each develops in the individual by a process of learning, though perhaps by maturation as well. Many of them are fundamental animal activities, which have taken on special and elaborate forms in the social life of man. They are dependable in man as well as in animals, present all over the world, and practically sure to be aroused in every individual. When aroused, they become activities in progress, and adjustments towards certain typical end results. They are, then, dependable motives. They are activities engaged in for their own sakes, and not simply as means to ulterior ends.

A list of such dependable motives would be worth having, and each should be traced back to its unlearned rudiments in the individual, and then traced forward through its modification and elaboration by learning and social influence. Any treatment of the subject, at the present time, is bound to be very sketchy, because the requisite genetic studies have not been made.

Organic needs. Each need is primarily a chemical or physical condition of the organism. Hunger is a depletion of the food materials within the body, thirst a depletion of water, asphyxia is an extreme degree of the depletion of oxygen and accumulation of carbon dioxide that motivate breathing. Fatigue is an accumulation of the waste products of muscular activity, and drowsiness or sleep-hunger may be akin to fatigue. Each of these organic conditions gives rise to a characteristic sensation. During organic hunger the stomach becomes active and gives the hunger pangs. Organic thirst gives the thirst sensation in the throat. Respiratory need is felt in the region of the lungs. Fatigue is felt in the muscles and joints and more generally all over the body. Drowsiness is felt in the head region and throughout the body. Each of these sensations represents a stimulus applied to the nervous system and resulting in a brain set for a certain line of activity, or for inactivity in the cases of fatigue and drowsiness.

Each of these organic states, with its characteristic sensation and the corresponding brain set, forms the unlearned core of a whole system of activity. We might speak of hunger behavior, thirst behavior, breathing behavior, rest behavior, sleep behavior, as systems of activity developed from their several unlearned cores or nuclei. In the social life of man, each of these systems of activity becomes very extensive. Think of all the activities connected with food: hunting, agriculture, cooking, eating places, table manners, social festivities, the science of nutrition. No wonder the socially minded rebel

against calling the whole system of hunger behavior the "feeding instinct" or the "instinct of nutrition." But when they substitute such a term as "feeding habit," they jump from the frying pan into the fire, for the core and motivation of the whole system of activity remains as organic and unlearned today as it was in the most primitive times, or as it is in any animal. The whole trouble is one of names, and the best way out is to discard both misleading names, "instinct" and "habit," so as to clear the decks for recognizing both the unlearned core and the learned elaboration of each system of activity.

The individual, though so plastic and apt in learning, is by no means a mere learner, or simple clay to be molded by social pressure and convention. The organic needs are so many demands which the individual makes upon the environment, and since every individual makes these demands, society is compelled to meet them, and social customs, while molding the individual, must at the same time satisfy the individual.

We have not named all the organic needs. One other deserves brief mention. The warm-blooded animals, birds and mammals, have the remarkable power of keeping their internal temperature constant, at 98–99 degrees Fahrenheit in man, somewhat higher in birds, in spite of great variations in the external temperature and in spite of great variations in the amount of heat generated in the body by muscular exercise. Sweating and flushing of the skin are unlearned responses to heat, and prevent the body temperature from rising; paling of the skin and shivering are unlearned responses to cold and hinder the body temperature from falling. The organic need here is physical rather than chemical, but in other respects this need takes its place beside the others, and it gives rise to another behavior system with wide ramifications in society.

The sex motive. Mention has already been made of the

difficulty of isolating the unlearned core of this behavior system, because of the fact that sex maturity, especially in human beings, is not reached till so much opportunity for learning has occurred. The best studies are on animals, and the results are clearer in the female animal than in the male. At maturity, the female begins going through a series of cycles, called oestrous cycles, each cycle consisting of a briefer period of sex activity or readiness, and a longer period of sex inactivity. In each active period an egg or ovum is discharged from the ovary towards the womb, ready for fertilization. The active period is characterized in two ways: by great increase in general activity, and by specific sex activity. The general activity of the female white rat can be measured by placing her in a running-wheel like those often seen in squirrel cages, with a counter attached to show how much she makes the wheel go; and it is found that she is very much more active during the period of "heat" than at other times. Her specific sex activity can be measured by placing her in a cage so constructed that she must cross an electric grid and take a shock in order to reach the male, and counting the number of times, within half an hour, that she will take this punishment in order to reach him. In the inactive period of her cycle she will cross scarcely at all, but in the active period she crosses frequently and with little hesitation. Also, her behavior in the presence of the male is very different in the period of heat and in the inactive period. During the latter she fights off any male that makes advances to her, but during heat she is receptive and seductive. The male also, at sex maturity, responds to the active female as a young rat does not, by behavior different from that of the female but adapted to it. The male shows no periodicity, but is much more active in crossing the grid to the female after a day of sex deprivation than when satiated. The female periodicity of activity is due to a change of chemical state. A "hormone," i.e., a secretion from some gland circulating throughout the

body, is what makes the active period different from the inactive period. There are also hormones which are necessary for sex activity in the male.[2]

Now the hormones, the periodicity, the responsiveness to the behavior of the other sex, and the special sex behavior of each sex, are unlearned in the rat; and while conditions are somewhat different in the human, there is certainly an unlearned core of sex behavior there too. The main question is whether there is any native difference in external behavior between man and woman, or whether the differences that we are familiar with are wholly matters of social convention. There is a subtle difference between the young man and the young woman, in their behavior towards each other, and this difference seems to hold good in the various tribes and cultures, with all their differing laws and customs. The unlearned core of sex behavior probably includes the organic state due to hormones and the subtle difference in external behavior which makes each sex attractive to the other.

Sex behavior is subjected to so much repression and delay for economic and other social reasons that the sex motive is forced to find an outlet in behavior that is not directly sex behavior. Courtship is prolonged and made romantic. It is when the path of love is long and thorny that the young swain breaks forth into lyrics in praise of the lovely maiden. Sex attraction colors the behavior of any group where men and women participate. Some students of the matter have been so impressed by the wide ramifications of the sex motive in human conduct that they have attributed to it all the softer and lighter side of life, all literature, art, music, even all religion. But this is an exaggeration and overlooks the many other motives which are blended in the complex social life of mankind.

[2] G. H. Wang, *Comparative Psychology Monographs*, 1923, vol. 2, no. 6; F. A. Moss, *Journal of Experimental Psychology*, 1924, vol. 7, pp. 165–185; L. H. Warner, *Comparative Psychology Monographs*, 1927, vol. 4, no. 22.

The maternal motive or mother love. In many kinds of animals, though not by any means in all, one of the parents stays by the young till some degree of maturity is reached. In some fishes, it is the male that cares for the young; in birds it is often both parents. In mammals it is always the mother. Instinctively the mammalian mother feeds, warms and defends her young. A hormone plays a part here, as is seen from the spontaneous appearance of the mother's milk with the birth of the young. This hormone is present in the human mother too, and puts her into a special organic state. There is good reason to believe that the hormone has an effect on her feelings and mode of behavior. The great wave of tenderness that comes over the mother when she sees and holds her new-born baby certainly arises from her organic state. As an expectant mother, she may have been quite calm and cool towards the baby; she may even have felt antagonistic; but when the baby is born, she swings around promptly into strong mother love. In the few exceptions that occur there is some strong motivation against the child — some fear or bitterness that has got tied to the thought of this child, and that inhibits mother love. In spite of these few exceptions, mother love is about as dependable as any motive.

The mother's love for her child takes its start from this unlearned core, and grows by acquaintance with the child. The baby's cute little ways endear him more and more to the mother. By the time the baby is weaned, the learned loving behavior has taken such firm hold that it keeps on even after the special organic state of new motherhood has disappeared. But after the child is weaned and able to do for himself to some extent, he does not arouse the same wave of tenderness that he did as a little baby; and if a new little baby appears, the older child has to take second place for the time being, because it is the little, helpless baby that best fits in with the organic state of the mother.

No doubt most of the details of child care are learned by the mother, but certain elementary desires do not have to be learned — to cuddle and feed the baby, to seek to stop its crying, to fight off anyone who threatens it. No one can seriously maintain, for example, that the baby's crying is naturally soothing or indifferent to the mother, and that she is simply following social convention when she seeks to quiet the baby. She may school herself to let the baby cry, but she doesn't have to be told to pick him up when he cries. In short, the unlearned maternal behavior is of the positive, eager type.

The escape motive — shrinking from injury — fear. The flexion reflex of the arm or leg, which pulls it away from a pinch, prick or burn, is one of a host of simple avoiding reactions — winking, scratching, coughing, sneezing, clearing the throat, wincing, limping, squirming, changing from an uncomfortable position — most or all of them unlearned reactions. The stimulus for each is felt as an irritating sensation. When the simpler avoiding reactions fail to remove the irritation, they are repeated more vigorously or replaced by some larger avoiding reaction, such as cowering, shrinking, clinging to another person, dodging or warding off a blow, huddling into the smallest possible space, getting under cover, running away. Of these larger avoiding reactions, clinging appears in the new-born, but the others may be partly learned.

Often a peculiar organic state is set up by efforts to escape from pain or injury, the hormone of the adrenal glands being poured copiously into the blood stream, with the result that the organism is thrown into a keyed-up, excited condition. This is the condition sometimes labelled the "emotion of fear," which we will examine more closely in the following chapter.

The little baby fears nothing, or almost nothing. He makes avoiding reactions to stimuli that are directly irritating, but not to stimuli that are simply signs of danger. You can easily

get avoiding reactions from a new-born baby by producing pain and discomfort; and you can get the clinging response by letting the child slip when he is in your arms. You get crying and shrinking at loud, grating noises. But that is about all. The fears of older people do not appear in the little baby. For example, the baby is not afraid of a furry animal, or of a snake.

If the snake test (a large but harmless snake, carried around by the experimenter, who invites every one to feel his nice smooth, hard skin) is tried on people of different ages, no child under two years shows any fear or concern; at three or four they begin to be somewhat wary, and within the next few years some of them begin to show definite avoidance, both boys and girls. College students show more intense fear, and more commonly, than boys and girls of ten or younger.[3]

How shall this increase of fears with age be explained? From the experiment on conditioned fears, in which the fear of a furry animal was built up in a baby by sounding the rasping noise whenever the baby reached for the attractive animal, we see how fears may be learned. If a child has been bitten by a dog, be may become afraid of dogs. More often he becomes afraid from being warned by older people or from observing their fear responses. Thus children who are originally not the least bit afraid of thunder and lightning may pick up a fear of them from adults who show fear during a thunderstorm.

But just as development is partly maturation and not entirely learning, so the increase of the child's fears with age is not entirely due to such accidental "conditionings." Part of the increase is due to the child's growing up. At first he cannot be frightened by way of his eyes, but as he comes to use his eyes more effectively, he is startled by sudden movements such as the jump of a frog or of a jack-in-the-box. At first he understands little of what is going on around him, but as he under-

[3] H. E. Jones and M. C. Jones, *Childhood Education,* 1928, vol. 5, p. 136.

stands more and participates more, he finds more need for caution.

Fear stimuli, then, fall into three classes: (1) irritating stimuli, not dependent on learning; (2) conditioned or associated stimuli, dependent on learning; (3) stimuli or situations calling for sudden readjustment of the individual, dependent less on specific learning than on the child's general growth in knowing what is going on and participating in it.

In later childhood, adolescence, and early adult life, many fears are outgrown, overcome, or more or less completely suppressed. Some of this change is the result of still better understanding of what is going on. Knowledge of astronomy, for instance, removes the fear of eclipses of the sun, and the advance of science in general does away with many fears which formerly beset mankind. Some fears are outgrown just because the individual has become larger and stronger. And some fears are suppressed and more or less completely overcome in obedience to the social code of adults that ridicules those who still show childish fears. This social code is different for the young man and the young woman, and adolescent girls frankly admit many fears which the boy of the same age is ashamed to admit. The suppression may do away with the external signs of fear without wholly removing the internal organic state. So, an adult who handles the snake with apparent calm may show beads of perspiration on his forehead; and a person who can stand on the brink of a precipice without panic may yet feel much more at ease when he has retired. Nevertheless, such fears are often really overcome and left behind.

The combat motive — fighting — anger. Hold the new-born infant's arms tightly against its sides, and you witness a very peculiar reaction: the body stiffens, the breath may be held till the face is "red with anger"; the child begins to cry and then to scream; the legs are moved up and down, and the arms, if they can be got free, make striking or slashing movements. In

somewhat older children, any sort of restraint or interference with free movement may give a similar picture, except that the motor response is more efficient, consisting in struggling, striking, kicking, and biting. It is not so much pain as interference that gives this reaction. You get it if you take away a toy the child is playing with, or if you forbid the child to do something he is bent on doing. In animals, the fighting response is made to restraint, to being attacked, or to being interfered with in the course of feeding, or mating, or in the care of the young. The mother lioness, or dog or cat or hen, is proverbially dangerous; any interference with the young leads to an attack by the mother. The human mother is no exception to this rule. In human adults, the tendency to fight is awakened by any interference with one's enterprises, by being insulted or got the better of or in any way set down in one's self-esteem.

The stimulus may be an inanimate object. You may see a child kick the door viciously when unable to open it; and grown-ups will sometimes tear, break or throw down angrily any article which they cannot make do as they wish. A bad workman quarrels with his tools. Undoubtedly, however, interference from other persons is the most effective stimulus.

Part of the response to this stimulus may be internal, an organic state which seems to be the same as in fear, and which here forms part of the emotion of anger. The angry emotion is absent from cold-blooded fighting.

The motor response, instinctively consisting of struggling, kicking, etc., as already described, becomes modified by learning, and may take the form of scientific fistwork, or the form of angry talk, favored by adults. Or, the adversary may be damaged in his business, in his possessions, in his reputation, or in other indirect ways.

But fighting is not always defensive. Sometimes it is aggressive, and without provocation. Consider dogs. The mere presence of another dog is often enough to start a scrap, and a

good fighting dog will sally forth in search of a fight. Fighting of this aggressive sort is a luxury rather than a necessity. There can be no manner of doubt that pugnacious individuals, dogs or men, get more solid satisfaction from a good fight than from any other amusement. You see people "itching for a fight," and actually "trying to pick a quarrel," by provoking some other person who is strictly minding his own business and not interfering in the least. A battle of words usually starts in some such way, with no real reason, and a battle of words often develops into a battle of tooth and nail. Two women were brought before the judge for fighting, and the judge asked Mrs. Smith to tell how it started. "Well, it was this way, your honor. I met Mrs. Brown carrying a basket on her arm, and I says to her, 'what have ye got in that basket?' says I. 'Eggs,' says she. 'No!' says I. 'Yes!' says she. 'Ye lie!' says I. 'Ye lie!' says she. And a 'Whoop!' says I, and a 'Whoop!' says she; and that's the way it began, sir."

We must recognize aggressive fighting, then, as well as defensive, and both sorts are important in a study of motivation.

The development of angry behavior is parallel to that of fear. First the primitive and unlearned angry response of the baby to physical restraint. Then learning, which gives new stimuli to arouse anger and new ways of fighting, as the child grows to understand people and the indirect ways in which they interfere with his doings. Finally, the outgrowing and suppression of angry behavior, carried by some individuals almost to the point of complete elimination.

Up to this point in our list of the "dependable motives," we have found some organic state, usually of a chemical nature, playing an important part in each type of motivating activity. But there are certain other motives, no less dependable, for which no organic state is known.

Play was sufficiently considered a few pages back. Certainly the play motive is very dependable in children. We can

almost believe in an organic state underlying playfulness. It is when the child is well, rested, and buoyant that his play is most active. This organic condition of "feeling fine" is sometimes called "euphoria."

Laughter might seem too trivial a matter to deserve a place in our list of dependable motives. But think of the rôle of laughter in social life, think of all the professional laugh-makers, and of all the hard-earned cash expended in the hope of getting a good laugh!

Laughter is certainly an unlearned activity, even though it does not appear at birth. Smiling appears soon after birth, but the complex respiratory movement of laughing emerges some months later, and is a good instance of maturation.

The most difficult question about laughter is to tell in general psychological terms what is the stimulus that arouses it. We have several ingenious theories of humor, which purport to tell; but they are based on adult humor, and we have as yet no comprehensive genetic study of laughter, tracing it up from its beginning in the child. Laughing certainly belongs with play, and possibly the stimulus is no more definite, at first, than that which arouses other playful activity. The baby seems to smile, at first, just from good spirits (euphoria). The stimuli that, a little later, arouse a burst of laughter have an element of what we may call "expected surprise" (as dropping a rattle and exploding with laughter when it bangs on the floor, and keeping this up time after time), and this element can still be detected in various forms of joke that are effective mirth-provokers in the adult. But why the child should laugh when tickled, at the same time trying to escape, is a poser. Many students of humor have subscribed to the theory that what makes us laugh is a sudden sense of our own superiority. The laugh of victory, the laugh of defiance, the laugh of mockery, the sly or malicious laugh, support this theory, but can it be stretched to cover the laugh of good humor, the tickle laugh, or

the baby's laugh in general? That seems very doubtful, and we must admit that we do not know the essential element in a laughter stimulus. One thing is fairly certain: that, while laughing is unlearned, we learn what to laugh at, for the most part, just as we learn what to fear.

Exploration and manipulation were discussed before, but should have a definite place in our list of dependable motives. They deserve mention not only because they are dependable, and not only because in their simplest forms they are unlearned, but because of their immense importance in the development of knowledge and skill.

Social motives. Man is so much a social animal that even such an organic need as hunger gives rise to social behavior. Fear and anger are perhaps oftener aroused by other people than by any other stimuli. Play, which with the little child is largely solitary, becomes socialized during childhood and remains so in adult life. Sex behavior brings people together in pairs, and maternal behavior gives us homes and families. Thus many of the dependable motives are social to some degree. But the question remains whether there is any primary social motive. The herd instinct, or gregarious instinct, is often spoken of as such a motive. Different kinds of animals differ in gregariousness, and man would seem to belong with the more gregarious animals, like the deer and the wolf, rather than with the so-called solitary animals like the lion. But it is very difficult to decide whether man's preference for living, working and playing in groups is learned or unlearned. From his prolonged period of dependence, the human child is bound to be "conditioned" to group life, even if he were naturally indifferent to it. It is true that the "conditioning" sometimes operates to drive an individual out of society and make him prefer solitude. But, on the whole, and whether learned or unlearned, the liking for social life is a very dependable motive in human beings. It is a liking not simply for being in com-

pany but for participating in the activity of the group. The child is lonely even in company, unless he is allowed to participate in what the others are doing, and the same is often true of the adult. The dependable motive, then, is the liking for social activity rather than that for simply herding together.

The mastery or self-assertive motive. Now we come to a motive that is certainly dependable, though it doesn't appear in any one special kind of activity, like eating or fighting, but crops up in all sorts of behavior, dealing either with other people or with animals, machines, or any kind of objects that can be managed. It appears in the more aggressive form of liking to command, to lead, to dominate the situation, to master and manage the object, and in the more defensive form of dislike to be commanded or mastered or defeated in any enterprise. Some people are not specially anxious to dominate, but yet hate to be dominated.

Now this mastery motive cannot be wholly a learned affair. Practically all the "conditioning" that the child gets would tend towards making him submissive and not masterful. He starts as a little, dependent creature, surrounded by big creatures who do everything for him but expect him to yield and obey. But the child shows from an early age that he has a will of his own and wants his own way in opposition to the commands of other people. His independent spirit is not learned. Some children, to be sure, are more "contrary" than others, but there probably never was a child without a good dose of disobedience in his make-up. In youth, with the sense of power that comes from adult size and strength, the independent spirit becomes still stronger, with the result that you seldom find a youth or an adult who can take orders without some inner resistance and resentment.

But the child shows the aggressive as well as the defensive type of masterfulness. Even the baby gives orders and demands obedience. Less direct ways of dominating other people

are discovered as the child grows older. Showing off is one way, bragging is one, doing all the talking is one; and, though in growing older and mixing with people the child becomes less naïve in his manner of bragging and showing off, he continues even as an adult to reach the same end in more subtle ways. Going about to win applause or social recognition is a seeking for domination. Anything in which one can surpass another becomes a means of self-assertion.

Rivalry and *emulation*, sometimes accorded a separate place in the list of motives, seem well enough provided for under the general head of self-assertion. They belong on the social side of assertive behavior, i.e., they are responses to other people and aim at the domination of other people or against being dominated by them.

Thwarted self-assertion deserves special mention, as the basis for quite a number of queer emotional states. Shame, sulkiness, sullenness, peevishness, stubbornness, defiance, all go with wounded self-assertion under different conditions. Envy and jealousy belong here, too. Shyness and embarrassment go with self-assertion that is doubtful of winning recognition. Opposed to all these are self-confidence, the cheerful state of mind of one who seeks to master some person or thing and fully expects to do so, and elation, the joyful state of one who has mastered.

Masterful behavior is directed not only towards other people, but also towards all sorts of things that can be managed. The child's playful manipulation has an element of masterfulness in it, for he not only likes to see things perform, but he likes to be the one that makes them perform. If he has a horn, he is not satisfied till he can sound it himself. The man with his automobile is in the same case. When it balks, he is stimulated to overcome it; but when it runs smoothly for him, he has a sense of mastery and power that is highly gratifying. Chopping down a big tree, or moving a big rock with a crowbar, affords the same kind of gratification; and so does cutting

with a sharp knife, or shooting with a good bow or gun, or operating any tool or machine that increases one's power. Quite apart from the utility of the result accomplished, any big achievement is a source of satisfaction to the one who has done it, because it gives play to aggressive self-assertion. Many great achievements are motived as much by the zest for achievement as by calculation of the advantages to be secured.

Submissive behavior, hero worship and willingness to follow the leader appear so much like a necessary counterpoise to self-assertion that we are tempted to include submission in our list of primary motives. But the child has so much opportunity to *learn* to submit that a case for unlearned submissiveness can scarcely be made out. He often has to give up, because things are too hard to manage. Adults enforce obedience, and society ridicules him into conformity with its manners and customs. So his independent spirit and resistance to domination are trained out of him to some extent.

What can be said in support of a *primary* or unlearned submissiveness amounts to this: yielding is an active response, not merely passive and forced upon the individual. No external force can absolutely compel him to yield, unless by clubbing him on the head. So long as his brain, nerves and muscles are able to act, he can keep on struggling. Giving up is his own act, and it brings relief from the effort and strain of struggling. Unless the child had the ability to yield, as a natural reflex, how could he ever start learning to yield? Conditioned reflexes are built upon natural reflexes. This is really a strong argument for an unlearned core of submissive behavior.

Whether the ability to submit is partially unlearned or wholly the result of training, it is surely an asset to the individual in his big task of adapting himself to the environment. Absolute stubbornness would prevent all learning by trial and error. An absolutely stubborn cat in a cage would persist in pushing its nose between the bars — if that were its first re-

sponse to the situation — and would never find the latch that opens the door. Trial-and-error means persisting in the main enterprise, while giving up, one by one, the unsuccessful lines of attack. Adaptability, docility, openness to new facts and ideas, impartiality and fairness, all have in them an element of submission.

Effort and overcoming obstruction. A kind of masterful behavior that has not yet been described deserves special attention because of its importance. It is seen in a very primitive form in the resistance offered to being pushed or pulled. Take the baby's foot and move it this way or that, and you will find that the leg muscles are resisting this extraneous movement. Obstruct a movement that the baby is making, and additional force is put into the movement, overcoming the obstruction. These are natural or unconditioned reflexes.

A more complex reflex of the same sort is the movement of straining: a full breath is taken, the glottis is closed preventing the escape of air from the lungs, and then a strong movement of expiration is made. The most obvious result of this peculiar movement is to produce pressure in the abdomen and so assist in the evacuation of the bladder or rectum; and that is the way the baby first uses it. But it also sets the chest and stiffens the whole trunk for lifting a heavy weight or for any great muscular strain, and it regularly enters into any such muscular effort. It is the typical reflex of effort, a natural reflex that becomes attached to all sorts of effortful reactions, and conditioned to all sorts of difficult situations. Careful observation will show that it occurs dozens of times a day, even where the effort required is more mental than muscular.

There are many other movements of effort: gritting of the teeth, clenching the fist, stiffening the neck, frowning in the effort to see better, leaning forward for the same purpose, even when, as at a football game, getting a foot or two nearer the show cannot make any noticeable difference to the eyes. Ask a

child just learning to write why he grasps the pencil so tightly, why he bends so closely over the desk, why he purses his lips, knits his brow, and twists his foot around the leg of his chair, and he might answer, very truly, that it is because he is *trying hard*. All this needless muscular effort shows the release of extra energy by the difficulty encountered.

Obstruction encountered releases extra energy. Let the individual embark upon any activity that seems to call for a moderate output of energy. The activity may be lifting a weight, or reading a book, or solving a puzzle. Now let the task present unexpected difficulty. The individual gives up, or else he puts in more effort and overcomes the obstruction. The latter, self-assertive response is more likely to occur, unless, indeed, the obstruction is very great. This statement is so important, if true, that it should receive some experimental support, to fortify the every-day observations already cited in its behalf.

A weight-lifting experiment. A weight was suspended from a cord that passed over a pulley and ended in a handle. The subject grasped the handle and lifted the weight by flexion of the arm, the biceps being the chief muscle used. He was told to lift the weight with his utmost force, and meant to do so. Yet, when the experimenter increased the weight, the subject increased his force; and when the experimenter decreased the weight, the subject involuntarily decreased his force. The subject kept the speed of his movement fairly constant, as if following his own standard as to how rapid the movement should be, and varied his muscular force to match the weight encountered. The same result was obtained from all the individuals tested. The greater the obstruction encountered, then, the greater is the output of muscular energy.

A distraction experiment. A subject is isolated in a quiet, bare room, free from all distractions, and starts a rather pains-

taking typewriting job. Suitable apparatus records the speed and accuracy of his work, and also his breathing and the force with which he strikes the keys. He is told to work as rapidly as possible. After he has worked for a time in quiet, suddenly loud bells and buzzers begin to sound, one after another, from all parts of the room. He is disturbed at first, but soon realizes that the experimenter in the adjoining room is switching on all this noise as a test. Consequently the subject makes an extra effort and usually overcomes the distraction so successfully as actually to increase his speed, with no loss of accuracy. When quiet is restored, after a few minutes, he relaxes his efforts and slows up a little. How did the subject overcome the distraction? The pressure record shows that he pounded the keys harder during the noisy period; and the breathing record shows that he tended to speak the letters that he was writing. He overcame the distraction, then, by throwing more energy into his performance.[4]

Any experiment on learning a new performance shows effort to overcome the difficulty of the unaccustomed task. When the beginner has passed the first cautious, exploratory stage of learning, he begins to "put on steam." He pounds the typewriter, if that is what he is learning, spells the words aloud, and in other ways betrays the great effort he is making. Once he has mastered the difficulties of the performance, he reaches a free-running stage in which great effort is no longer required, unless it be for making a record. With reference to effort, then, we may distinguish three stages of practice: the initial, exploratory stage, the awkward and effortful stage, and the skilled and free-running stage.

As a general proposition, then, and one of the most general propositions under the head of motivation, we can state that obstruction encountered in carrying out any activity stimulates the individual to put more energy into the activity.

[4] Reference: J. J. B. Morgan, *Archives of Psychology*, no. 35, 1916.

THESE "DEPENDABLE MOTIVES" ARE NOT THE ONLY SPRINGS OF ACTION

We have now gone through quite a list of behavior systems, each of which, when excited to activity, tends to complete itself and to draw in other activities as preparatory reactions. Each furnishes a dependable motive. Now it would seem fine and systematic to go on to say that these motives are the mainsprings of all human activity, and that all activity was motivated by one or more of them. Such statements have in fact been made. Sometimes the list of primary motives has corresponded rather closely to our list above, sometimes it has been more extensive, recently it has usually been made as short as possible. Sometimes hunger, sex and fear and anger have been singled out as the only fundamental motives.

Your author's contention is that any such system is radically wrong. These few motives are not like so many mainsprings of a complicated clock, one or another of which must be driving the works at any time. They may all be inactive at a given moment, and still the individual may be active. He may not be hungry or thirsty or angry or afraid or sexually eager, and yet he may be busily engaged in some activity. Provided he has got well started in some activity, he has a zest for carrying it through. A motive, we said, was an activity in progress, and any activity in progress may be a motive for the time being. If a person has started to catch the train, his motive for the next few minutes is to catch that train. If he has started to solve a puzzle, his motive for the time is to solve that particular puzzle. To be sure, the exploring and mastering motives are likely to be aroused in the course of any activity, even when they had nothing to do with starting it off; but that simply means that extra motives are likely to come into the game during its progress. The main motive of any activity is the carrying forward of that activity.

Motives are often very specific. A person is not simply hungry, but he longs for some particular food. He is not only lonely, but he longs for a particular person's company. Before a child can tell what he wants, you may have trouble in finding just the toy that he requires at a given moment. You bring him one; he turns away; another, and he pushes it aside; a third, and he breaks into loud complaint. Finally you bring him one that is just what he wants.

It would be impossible to explain the variety of human activities in terms of a few primary motives. The varieties of food and cooking cannot be explained by the hunger motive, nor the varieties of clothing and housing by the need for protection against the elements. The endless variety of art objects cannot be explained by any of our dependable motives.

To predict what response an individual will make to a given stimulus, you need indeed to know which one, if any, of our dependable motives is active in him at the moment, but you need to know his activity in progress much more specifically.

But, the query may be raised, if this list is so far from a complete list of human motives, why have we labored over it so long? Well, because these motives are dependable, and because they are primitive. They are universal, while the countless particular motives differ from one culture to another, and from one individual to another.

Likes and dislikes. Besides the dependable motives, each of them belonging to a type of activity, there are learned and unlearned tastes, or likes and dislikes, that seem rather passive and independent of any activity in which the individual may be engaged. Sweet is liked and bitter disliked, just for themselves. Certain odors are liked and others disliked. Bright colors are liked; smooth tones are liked, simple rhythms are liked. These likes and dislikes do not have to be learned. Liking for lemonade, or coffee, or olives or cheese has to be

acquired by learning; and the same is true of the liking for subdued colors or for close harmonies in music.

Such likes and dislikes are motivating factors in the development of the arts. The culinary art could not have developed in the absence of pleasant tastes, nor the perfumer's art in the absence of pleasant odors. The color art is certainly dependent on human love of color, and music on love for tones and rhythm. Once these arts are in existence, the artists find opportunity in them for the mastering of technique, and for self-display and social prestige. But surely the arts are not accounted for by the self-assertion of the artists. The artists themselves would not go far without a love for the tones and colors and other elements of their arts.

Much the same can be said for the sciences. Some individuals, for instance, have a liking for numbers and other mathematical elements. They do, indeed, find opportunity for exploration, mastery and self-display in mathematics; but beyond and prior to all that, they are fascinated by numbers, geometric forms and algebraic transformations, and find something really beautiful in the relationships that reveal themselves.

We must admit also a liking for people, quite apart from the impulse to dominate them and quite apart from sex interest or motherly interest. The liking is not simply gregariousness, but rather a liking for their different personalities and ways of acting.

Such likes and dislikes help towards a fuller understanding of motivation than is afforded by the list of dependable motives alone. But they also are not specific enough to account for the particular goals towards which the individual strives.

The motivation of any extensive activity is likely to be complex. Take the "economic motive," for example. This cannot be identical with the hunger motive, for the individual works even when he is not hungry, and the dread of starvation

may never have been implanted in him by his experiences. It cannot be identical with the sex motive, for he works when not sexually excited, and his plans for marriage may be too vague as yet to drive him to work. The exploring motive undoubtedly plays a part while he is becoming acquainted with a new occupation, and the mastery motive when he faces the difficulties of his work, or when he is in danger of being outclassed by his fellows. But if his job suits him, he finds the actual operations interesting for their own sake; and on any particular day he has a definite goal to reach and becomes absorbed in the particular activity leading to that goal. Without this absorption in the task in hand, the more general motives would lead to only half-hearted activity.

The college student's motivation is apt to be rather vague and nebulous. Economic goals are distant, local prestige among his fellows may not depend to any great extent on scholastic achievement, the professors, though rather dreadful, do not inflict corporal punishment as an appeal to the fear motive, and unless the student gets deep enough into a subject to feel its fascination, his study is listless and decidedly lacking in zest. It is a pity when the young man or woman of ability gets through college without feeling the fascination of some of the noblest enterprises of mankind, and without developing a zest for high-grade intellectual activity.

CONFLICT OF MOTIVES

The individual is complex, with many different activities that can be aroused. The environment is complex, affording stimuli for various activities. Conflict, then, is sure to arise, and a selection must be made between inconsistent activities.

Even in reflex action, as we saw before, selection has to be made. The organism does not attempt to make inconsistent movements at the same time. Stronger stimuli have the advantage over weaker stimuli, readier responses have the ad-

vantage over the less ready, and the balance of advantage favors one response above its alternative. Thus one response is automatically selected at any moment, but the advantage is apt to shift shortly to the other alternative. This type of selection, or decision, is fundamental.

Conflict is more serious in purposive behavior. As we anticipate the results of a proposed activity, some of these results may seem desirable and others undesirable. At one moment the desirable results stand out and we start to plunge into the activity; but the next moment the undesirable results come to the fore, and we shrink back from the activity. Or, we may have to choose between two activities, both of which promise well; or again, we may have to make a choice of evils.

The state of indecision. When a conflict arises, the first result is a state of indecision, this " state " being really a complex activity, often very intense and often very confused. This state works itself out, somehow, into the state of being committed to one of the alternative lines of action.

The state of indecision may amount simply to *hesitancy*, when the conflict is between doing something, on the positive side, and fear, shyness or inertia on the negative side. Hesitancy is apt to occur before getting out of bed in the morning, or before taking a plunge into cold water, or before speaking out in meeting or in a general conversation. To get action, the positive motive must be stronger than the negative, at least for an instant.

Vacillation is a more complex state of indecision, when the choice lies between two desirable goals, or between two evils. Old Buridan's celebrated problem of the ass, placed halfway between two bundles of hay — whether he must not starve to death from the exact balance of the two opposing motives — is a parable to fit the case of vacillation. Probably the poor ass did not starve — unless he richly deserved his name — but

he may have ended the uncomfortable state of vacillation by running away altogether, as a human being is sometimes so much disturbed at having to decide between two invitations for the same day as to decline both, and go fishing. Vacillation is certainly unpleasant. We want action, or else we want peace, but vacillation gives us neither. In spite of its irksomeness, we seem sometimes almost powerless to end it, because as soon as we have about decided on the one alternative, what we shall miss by not choosing the other comes vividly to mind, and swings the pendulum its way.

However it comes about that a decision is reached, it usually is reached, and then it usually sticks. A student may vacillate long between the apparently equal attractions of two colleges, but when he finally decides on one, the advantages of the other lose their hold on him. Now he is all for one and not at all for the other. Having identified himself with one college, he has completely altered the balance of attractions, his self-assertion now going wholly on the side of the chosen college, and even leading him to pick flaws in the other as if to reinforce his decision. Some people, indeed, are abnormally subject to vacillation and never accept their own decisions as final, but normally there are strong influences tending to maintain a decision, once it is made: the unpleasantness of vacillation; the satisfaction of having a definite course of action; and self-assertion, because *we* have decided, and now this course of action is *ours*.

The process of decision. While the state of indecision and the final state of decision are very different, the process of passing from one to the other is often difficult to trace. There is a sort of mental exploration of the alternatives, but the process differs from one case to another.

Deliberation. Sometimes each alternative is pictured as well as possible, and weighed against the other. This is ideally rational, but often impracticable, for lack of knowledge

of how each line of action would turn out. Even if practicable, deliberation may be too irksome to pursue to the bitter end. Perhaps the most common process is a sort of partial deliberation, the two alternatives appealing to us by turns till at some moment one of them makes so strong an appeal as to secure the decision.

Incubation of a decision. When a deadlock arises between alternative courses of action, the most rational procedure is usually the same that was found useful in the recall of a forgotten name or in the solution of a difficult problem:[5] to let the matter rest for a time, and perhaps sleep over it — after which we may find that one alternative has lost its momentary attractiveness and the other holds the field.

Arbitrary decision. Sometimes a deadlock is so irritating and humiliating, almost, that we say, "Any decision is better than none; here goes, then; *this* is what I will do," so breaking the deadlock by what seems to be a mere toss-up.

Does the decision always follow the stronger motive? Logically, it would seem that the stronger motive must prevail. But motives have a way of bringing in allies, and then the question becomes, which *team* is the stronger. A primitive craving, pitted against self-denial, would have the advantage, except that fear of ridicule, self-respect, and loyalty to another individual or to one's social group, may line up on the side of the weaker motive and give it the decision.

What becomes of the rejected motives? If you ask a person who has just fought his way through from a state of indecision to a state of decision to reopen the question and consider whether the rejective alternative might not be better, he is very unwilling to go back into the fight and turmoil; and if he does attempt to reopen the question, he usually finds the rejected alternative almost wholly lacking in pulling power. The process of decision has deadened the rejected motive.

[5] See page 98.

Thus the rejected motives may simply *lapse* into an inactive state and be gradually forgotten.

A deeply rooted motive, which cannot be so easily eliminated, may often be quieted by *deferring* it, by assuring it that its turn will come later on. Sometimes it is *disguised* and then gratified, as when an outwardly courteous action contains an element of spite. Sometimes it is *sublimated* or granted a substitute gratification, as when the boastful boy, after having the conceit taken out of him by his fellows, boasts no longer of himself but of his school, town or country. Sometimes it is tricked by *defense mechanisms,* such as the " sour grapes " mechanism, a pretending that we don't want what we can't reach, or what we have decided not to touch.

Some motives are *suppressed* in the sense emphasized by the psychoanalysts. A strong desire is made unconscious, while still remaining in the system and finding gratification in dreams and sometimes in disturbances of waking life. Sometimes the desire for something is replaced by a senseless fear of that same thing. Suppression grows out of an unresolved conflict.

The most adequate way of handling rejected motives is to *coördinate* them with accepted motives — to harness them into teams and set them to work. This cannot always be done; for example, if a young woman has two attractive suitors, she might find difficulty in harnessing them together. But when the boastful boy becomes a loyal and enthusiastic member of a school, his self-assertive motive is combined with social motives into an effective team. Probably a motive can be sublimated only by combining it with other motives.

These various ways of handling a rejected motive can be illustrated in the case of the sex motive. It so happens, partly because modern economic and educational conditions enforce a delay in marriage — and in part simply because there are so many attractive people in the world — that the cravings of sex

must often be denied. What becomes of them? Of course the sex motive is too deep-seated to be eradicated or permanently to lapse into a dormant state. But the fascination for particular individuals may so lapse or be forgotten. Certain people we remember, once in a while, with half-humorous and certainly not very poignant regret. Deferring the whole matter till the time is ripe works well with many a youth or maiden. Combined with social interests, the sex motive finds sublimated satisfaction in a great variety of amusements, as well as in business associations between the sexes. Introduce a nice young lady into an officeful of men, and the atmosphere changes, often for the better, — which means, certainly, that the sex motive of these men, combined with ordinary business motives, is finding a sublimated satisfaction. The sex motive thus enters into a great variety of human affairs. Defense mechanisms are common in combating unacceptable erotic impulses; the sour grapes mechanism sometimes takes the extreme form of a hatred of the other sex; but a very good and useful device of this general sort is to throw oneself into some quite different type of activity, as the young man may successfully work off his steam in athletics. This is not sublimation, in any proper use of that term, for athletic sport does not gratify the sex tendency in the least, but it gratifies other tendencies and so gratifies the individual. It is the individual that must be satisfied, rather than any specified one of his tendencies. As regards coördination, the fact was illustrated just above that this method would not always work; but sometimes it works immensely well. Here is a young person (either sex), in the twenties, with insistent sex impulses, tempted to yield to the fascination of some mediocre representative of the other sex. Such a low-level attachment, however, militates against self-respect, work, ambition, social sense. Where is the coördination? It has to be found; some worthy mate will harness all these tendencies, stimulating and gratifying sex

attraction, self-respect, ambition, and others besides, and coördinating them all into the complex and decidedly high-grade sentiment of love.

WILL

When we use such a term as "the will," we must remember what was said in the first chapter regarding the nouns used in psychology. Will is not a thing or machine, but a way of acting. It is a verb or adverb, rather than a noun. To will is to decide between conflicting motives, or it is to overcome obstruction by effort, or it is to enter on a course of action purposely and with anticipation of the goal. The three sections of the present chapter, dealing with purposive activity, with effort, and with conflict of motives, correspond to the appropriate content of a chapter on the will.

Abulia — "no will" — is an abnormal degree of lack of zest for action. Along with it go timidity and lack of social force, proneness to rumination and daydreaming, and often a feeling of being compelled to perform useless acts, such as doing everything three times or continual washing of the hands. Abulia is not just a comfortable laziness, but is attended by a sense of humiliation and inferiority. It shows itself in excessive hesitation and vacillation and in failure to accomplish anything of consequence. Sometimes the subject expends much effort, but fails to direct the effort towards the execution of his purposes. Some authorities have ascribed abulia to inertia or "low mental tension," some to an overdose of fear and caution, some to the paralyzing effect of suppressed desires still living in the "unconscious." Mild degrees of it, such as are not uncommon, seem sometimes to be due to the gap that is bound to exist between the end one has in view and the means one must take to start towards that end. One has zest for reaching the goal, but not for the preliminaries.

An author, whose case was studied because he was accom-

plishing so little, was found to follow a daily program about as follows. He would get up in the morning full of confidence that this was going to be a good day, with much progress made in his book. Before starting to write, however, he must first have his breakfast, and then a little fresh air, just to prepare himself for energetic work. On returning from his walk, he thought it best to rest for a few moments, and then one or two other little matters seemed to demand attention; by the time these were done, the morning was so far gone that there was no time for a really good effort, so he optimistically postponed the writing till the afternoon, when the same sort of thing happened, and the great performance had to be put over till the next day. This man did better under a regime prescribed by his medical adviser, who commanded him to write for two hours immediately after rising, and make this his day's work — no more and no less than two hours. The definiteness of this task prevented dawdling.

Securing action. How to get action, from yourself, or from others if you are responsible for their action, is a big practical problem. A few hints on the matter are suggested by what precedes.

How to get action from yourself — how to liberate your latent energies and accomplish what you are capable of accomplishing. A definite purpose is the first requirement; without that one merely drifts, with no persistency and no great energy. The goal should be something that appeals vitally to you, and something which you can attain; not too distant a goal; or, if the ultimate goal is distant, there must be mileposts along the way which you can take as more immediate goals; for a goal that can be reached by immediate action enlists more present effort. The student puts more energy into his study when the examination is close at hand; and, although this is regrettable, it reveals a fact in human nature that can be utilized in the management of yourself or others. A well de-

fined and clearly visible goal is a much better energy-releaser than vague good intentions.

The more clearly you can see and measure your approach towards the goal, the more action; thus it has been found in many different lines that the "practice curve method" of training gives quicker and better results than ordinary drill. In the practice curve [6] you have a picture of your progress; you are encouraged by seeing how far you have advanced, and stimulated to surpass your past record, and thus your immediate goal is made very definite. You cannot do so well when you simply "do your best" as when you set out to reach a certain level, high enough to tax your powers without being quite out of reach. You cannot jump so high in the empty air as you can to clear a bar; and, to secure your very best endeavor, the bar must not be so low that you can clear it easily, nor so high that you cannot clear it at all.

Do not say, "I will try." Say, "I will do it." The time for trying, or effort, is when obstruction is actually encountered. You cannot really try then, unless you are already fully determined to reach the goal.

Getting action from other people is the business of parents, teachers, bosses, officers, and to some extent of every one who wishes to influence another. In war, the problem of "morale" is as important as the problem of equipment, and it was so recognized by all the armies engaged in the World War. Each side sought to keep the morale of its own soldiers at a high level, and to depress the morale of the enemy. Good morale means more than mere willingness for duty; it means a positive zest for action. Some of the means used to promote morale were the following. The soldier must believe in the justness of his cause; that is, he must make victory his own goal, and be whole-hearted in this resolve. He must believe in the coming success of his side. He must be brought to attach

[6] See page 129.

himself firmly to the social group of which he forms a part. He must be so absorbed in the activities of this group as to forget, in large measure, his own private concerns. Not only must he be enthusiastic for cause and country, but he must be strong for his division, regiment and company. Much depends on the officers that directly command him. He must have confidence in them, see that they know their business, and that they are looking out for the welfare of their men as well as expecting much from them. Competition between companies, regiments, and arms of the service was a strong force tending towards rapid progress in training and good service in the field. Seeing that one's immediate group was accomplishing something towards the winning of the war was a powerful spur, while a sense of the uselessness of the work in hand strongly depressed the morale of a group. "Nothing succeeds like success"; morale was at its best when the army was advancing and seemingly nearing the goal. Morale was also wonderfully good when the enemy was advancing, provided your side was holding well with a good prospect of bringing the enemy to a halt and baffling his offensive. On the other hand, nothing was so hard on morale as the failure of an ambitious offensive of one's own side; the sense of futility and hopelessness then reached its maximum — except, of course, for the case of obviously approaching defeat. The conditions of trench warfare imposed a strain on morale: no progress, in spite of the danger and hardship, no chance to get at the enemy or do anything positive.

The manager of an industrial enterprise has the same problem of morale to meet. It is his business to get action from people who come into the enterprise as servants. The main difficulty with the master-servant relation is that the servant has so little play for his own self-assertion. The master sets the goal, and the servant has submissively to accept it. This is not his enterprise, and therefore he is likely to show little

zest for the work. He can be driven to a certain extent by fear and economic want; but better results, and the best social condition generally, can be expected from such management as enlists the individual's own will. He must be made to feel that the enterprise is his, after all. He must feel that he is fairly treated, and that he receives a just share of the proceeds. He must be interested in the purposes of the concern and in the operations on which he is engaged. Best of all, perhaps, some responsibility and initiative must be delegated to him. When the master, not contented with setting the main goal, insists on bossing every detail, continually interfering in the servant's work, the servant has the least possible chance of adopting the job as *his own*. But where the master is able, in the first place, to show the servant the objective need and value of the goal, and to leave the initiative in respect to ways and means to the servant, looking to him for results, the servant often responds by throwing himself into the enterprise as if it were his own — as, indeed, it properly is in such a case.

"Initiative" — that high-grade trait that is so much in demand — seems to be partly a matter of imagination and partly of will. It demands inventiveness in seeing what can be done, zest for action, and an independent and masterful spirit.

EXERCISES

1. Amplify the following statement: the individual's action in a given complex situation depends on the situation and on his own structure (dependent on his past development and ultimately on his heredity and his previous environment), and also on the individual's condition at the moment, consisting of his organic state and his activity in progress.

2. List 10 reflexes.

3. About what would you expect a sprinter's starting time to be, after the pistol shot? About what time would be required for the automobile driver to start applying the brake on suddenly seeing something that demanded immediate stopping of the car?

4. What "sets" were noticed, under other names, in studying memory?

5. List 5 common activities, simple or complex, and show that each can be considered as a motive. List 5 motives (or answers to the question, "Why did you do so?"), and show that each can be considered as an activity.

6. Explain the difference of meaning between the "law of combination" and the statement that "behavior usually comes in lengths."

7. Discuss the question whether behavior develops more out of the reflexes, or more out of the "random" and playful type of activity.

8. How is Lloyd Morgan's canon applied to the question of purposive behavior in animals?

9. Give a list of the "unlearned cores" of the several dependable motives.

10. What do you make out of this statement: "As the child's behavior becomes more objective, it becomes more purposive"?

11. Show how the mastery or self-assertive motive appears in a socialized form.

12. Debate the question (which is very debatable) whether all activity is driven by a few "dependable motives," or whether the position taken in this chapter is correct.

13. Analyze "will power" as it appears in the case history given in the first chapter, or in some other individual.

14. How can it be said that sublimation requires the coördination of two or more motives?

15. Give examples of effort at various levels of behavior.

REFERENCES

L. L. Thurstone, *The Nature of Intelligence*, 1924, opens with a discussion of stimulus and response, and of motive as an incomplete activity.

F. H. Allport, *Social Psychology*, 1924, pp. 42-83, presents a well-worked-out theory of motivation differing from the one adopted in the present chapter.

T. V. Moore, *Dynamic Psychology*, 1924, traces out motives and conflicts into their results in behavior; and M. K. Thomson, *The Springs of Human Action*, 1927, gives a comprehensive view of the subject.

CHAPTER VII

FEELING AND EMOTION

HOW THE LIFE OF FEELING IS RELATED TO THE INTERNAL AND EXTERNAL ACTIVITIES OF THE ORGANISM

What makes life worth living, or what makes it not worth living, is joy and misery — the joy of success, the glow of a noble action, the pleasure of agreeable friends and surroundings, or the gloom of failure, the ennui of finding nothing worth doing, loneliness and wretchedness and pain. It is not so much the motor performance of an act that makes it worth while as the excitement of approaching the goal, and the joy of final attainment. The mere motions of escape from danger would have little interest for the individual, except for the thrill of adventure and the relief of final escape. The overt behavior of courtship would mean little without the warmth of love. A quarrel would be flat and tame without the blaze of anger. From a purely objective and social point of view, it may make no difference how the individual feels, provided he goes through the right motions, but that is not the individual's way of looking at the matter. He evaluates what goes on in terms of his feelings, or, if he is broad and sympathetic, in terms of the feelings of other people as well.

It is true that the joys of life are not usually to be had by themselves. They come as the incidental result of activity directed to some other end than joy itself. The joy of success, or the misery of failure, either, is only to be had by those who have attempted to reach some goal. Feeling is inextricably bound up with doing — so inextricably that neither can be

rightly understood without the other. Feeling and emotion could not be omitted from the study of the individual without missing the point of the whole story from the individual's own point of view. A psychology without them would be on a par with a motion picture of an orchestra in action, without the sound.

THE FEELINGS

It is remarkable how many words there are in common use for different feelings and emotions. It would be no great task to find a hundred words, some of them no doubt synonymous, to complete the sentence, " I feel ——." Here are a few names of feeling and emotions, roughly grouped into classes.

Pleasure, happiness, joy, delight, elation, rapture
Displeasure, discontent, grief, sadness, sorrow, dejection
Mirth, amusement, hilarity
Excitement, agitation
Calm, contentment, numbness, apathy, weariness, ennui
Expectancy, eagerness, hope, assurance, courage
Doubt, shyness, embarrassment, anxiety, worry, dread, fear, fright, terror, horror
Surprise, amazement, wonder, relief, disappointment
Desire, appetite, longing, yearning, love
Aversion, disgust, loathing, hate
Anger, resentment, indignation, sullenness, rage, fury

The first word in each class is intended to give the keynote of the class. Other classifications could be made, and the classes could be made broader or narrower. Two broad classes, pleasant and unpleasant, would include most of the feelings. Still, you cannot say that the names simply designate different degrees of pleasantness or unpleasantness. Rapture and hilarity are both intensely pleasant, but scarcely the same; nor are fear and disgust the same, though both are unpleasant. The fact is that there are many kinds of pleasant feeling, and many unpleasant. Some of the words do not indicate whether the

feeling is pleasant or unpleasant; excitement may be happy excitement or unhappy excitement, and the same is true of expectancy and of surprise.

Wundt's three dimensions of feeling. This great leader in experimental psychology (who established the first active psychological laboratory in 1879) hoped to introduce some order into the motley variety of feelings by a system of three dimensions, analogous to latitude, longitude and altitude, by reference to which any actual feeling could be completely located. States of feeling can be arranged in a series from the most pleasant down through lower degrees of pleasantness and through a neutral zone over into the minor and then the major degrees of unpleasantness. This pleasantness-unpleasantness dimension was universally recognized and commonly assumed to be the only scale of feelings. But states of feeling can be arranged in another series, from the most excited to the most calm, quiet, subdued or numb. Wundt proposed, then, to take numb feeling as the reverse of excited feeling, and thus he had his second dimension, excitement-numbness. It is questionable, however, whether numbness can be regarded as opposite to excitement, and whether excitement can have an opposite. But the system would not be spoiled if we limited this dimension to positive degrees of excitement, ranging from the most extreme down to zero. For his third dimension, Wundt selected tenseness-release, which might also be called expectancy-release; and here again it is probable that expectancy diminishes down to zero, with no true opposite. If there is an opposite for expectancy, it is surprise. In expectancy you are waiting for something to happen, in relief or release that something has happened and abolished the expectancy, but in surprise the unexpected has happened and thrown you into quite a different state, whether or not it can properly be regarded as opposite to expectancy.

Wundt's scheme is certainly of value, even though it is al-

most too neat to fit all the facts of feeling. The three dimensions do not do justice to all the varieties of feeling; and there may be other dimensions worthy to be placed alongside of these three, such as desire-aversion, or such as familiarity-strangeness, already noticed in our study of recognition.

Feeling distinguished from overt action. Feeling seems like a passive state of the organism, rather than an activity; but it must be some sort of activity, since it depends on life. It is internal rather than overt activity. Whereas overt activity deals with external objects, feeling by itself produces no external results, but is confined within the individual himself. Yet feeling is not out of touch with the external situation. Unpleasant feeling favors getting rid of something and changing the situation; pleasant feeling favors keeping things as they are. But the feeling can be there without any definite overt action to maintain or change the situation; and on the other hand, overt action can occur with a minimum of feeling.

Feeling distinguished from observation of facts. Feeling is different from knowing. It does not consist in knowing facts of the world outside us, nor even in knowing facts regarding ourselves. A pain may be simply felt, or it may be observed as the indicator of some fact. A pain from the region of the stomach may be noticed carefully with the object of deciding whether it is the pain of indigestion or a hunger pang. But the infant takes stomach pain in what seems like a purely emotional way. Sensations, then, can be taken in two ways. In observation, we take them as indicators of facts, while in feeling we take them as a mass. Observed facts lead directly to overt response, while feeling has little direct effect on the external situation.

Feeling at one time is strong, or even overwhelming, while at another time it exists only as an undercurrent. Or we may call it a background, the foreground consisting of the facts observed and the acts intended at the moment. Only a few

among all the mass of sensations present at any moment are actually used as indicators of facts; the rest of the mass remains a mass, unanalyzed and indefinite. When you feel dull and heavy, if you notice the details of this feeling you become aware of dull pain in the eyes or neck or elbows or knees and of dull pressure in the chest and abdomen; and probably these various dull sensations, when present as an unanalyzed mass, constitute the general dull feeling.

The dull, uncomfortable feeling that is apt to occur during protracted sedentary work can be relieved by limbering up the joints with a little exercise, or by lying down for a few minutes and so easing up the heart and breathing action. The reason is probably that the various dull pains from the joints and from the interior of the trunk are removed by these means.

Feeling usually dominated by the life of facts and acts. The background of bodily feeling may be almost lost when one is absorbed in watching something, or doing something, or thinking of something. Scratches and bruises received during an active game may remain unnoticed till the game is over. Eye ache remains unnoticed while the story lasts. The audience sit motionless while the speaker is at his best, and start easing their several discomforts as soon as he becomes tiresome. Thus we see that feeling may be dominated and kept down by absorption in activity.

If we ask what kind of activity it is that pushes feeling into the background, we see that often it is external activity. It consists in watching something, or in manipulating something. Observation of facts and dealing with them belong together in what is sometimes called the life of relation with the environment, while feeling belongs with the internal life of the organism. Thinking, making use as it does of past observations and concerned as it largely is with planning for future action, belongs with observation and overt action in the life of external relations. Observation, thinking and acting differ from feel-

ing in being more analytical, or intellectual, or brainy. The skillful handling of a well observed situation is a brainier activity than merely feeling pleased or hopeful or discouraged. Now this brainy life of relation dominates at certain moments, and pushes the feeling of internal condition away into the background. At other times, the life of relation loses its grip or takes a rest, and feeling comes to the front.

Feeling is both sensory and motor. On the sensory side, it is the sensation-mass, unanalyzed and not utilized to indicate facts. On the motor side, it is the general set or attitude of the organism. Pleasantness is the general set for keeping the situation as it is, unpleasantness is the general set for getting rid of the situation. Excitement is the general set towards great activity, and expectancy is the general set of readiness for something to happen. In mere feeling, there is no set for any particular act. Feeling is diffuse and massive, on the motor as well as on the sensory side.

EMOTION

Emotion is a "moved" or stirred-up state of the organism. It is a stirred-up state of feeling — that is the way it appears to the individual himself. It is a disturbed muscular and glandular activity — that is the way it appears to an external observer, who sees the clenched fists and flushed face of anger and the tears of grief, or who hears the loud laugh of merriment and the tender tones of love.

Each emotion can be located in the tridimensional scheme of feeling, but such an analysis does not do full justice to the emotion. Fear is a state of excited, unpleasant expectancy, and mirth is excited, pleasant relief, but each is something more. Emotion is like feeling in being diffuse and massive, but an emotion has more definiteness than a mere feeling, especially on the motor side. Each emotion is a sensation-mass, and each is at the same time a motor set. Fear is a set for

escape, and anger for attack. These sets are more specific than the sets of mere pleasantness and unpleasantness.

How emotions are defined, and distinguished one from another. Though we all know the emotions as matters of personal experience, no one seems to be able to describe these feelings adequately. The muscular and glandular activities of different emotions have been described, but, as we shall see later on, quite different emotions may yield the same description. How, then, can we tell the emotions apart? How does it come about that we have that large vocabulary of names of different emotions? The dictionaries make no serious effort to describe the feeling or the bodily activity designated by each emotion name. The several emotions are distinguished, in practice, by stating the external situation in which each occurs and the type of overt response made to the situation. As Carr has said, "The various emotions can be readily identified and defined only in terms of the behavior situations in which they occur."[1]

Fear, accordingly, is the emotional response to danger; anger, to interference; joy, to success; surprise, to any unexpected happening; mirth is the emotion that goes with laughing; grief, with sobbing; and so on. Emotion, in general, is a stirred-up state of the organism, and any particular emotion is the stirred-up state appropriate to a certain situation and overt response.

It is true that the situation and overt response may occur without emotion. You may fight without anger, or dodge an automobile without fear, or even laugh without mirth. If the overt response is prompt and successful, emotion may not be aroused. If the brainy life of relation dominates the organism at the moment, the emotional response is minimized. But if the situation gets out of hand, then the emotion appropriate to the situation surges up. From the situation and overt re-

[1] *Psychology*, 1925, p. 278.

sponse, then, you cannot safely assert that the individual is undergoing an emotion; but you are reasonably sure that, if he is undergoing an emotion, it is the emotion that usually goes with that situation and that response, and you name the emotion accordingly.

How emotions are revealed — expressive movements. It is easy to tell when a baby is happy, by his cooing, smiling and playful behavior; and it is still easier to tell when he is mad. It is even easy to tell when a dog is happy; apparently the dog's tail is of use chiefly to express his feelings, and not as a practical tool in the life of relation. The human face, voice, gestures and postures are often very expressive. Smiling, laughing, scowling, pouting, sneering, sobbing, screaming, shouting, and dancing up and down, certainly accomplish no external result, except for their effects on other people. What is the sense of these movements? At first thought, the question itself is senseless, the movements are so much a matter of course, while on second thought they certainly do seem queer. What sense is there in protruding the lips when sulky, or in drawing up the corners of the mouth and showing the canine teeth in contempt? Darwin, after studying these movements in men and animals, suggested that they were survivals of acts that were once of practical utility in the life of the individual or of the race.

Shaking the head from side to side, in negation or unwillingness, dates back to the nursing period of the individual, when this movement was made in rejecting undesired food. The nasal expression in disgust was originally a defensive movement against bad odors; and the set lips of determination went primarily with the set glottis and rigid chest that are useful in lifting heavy weights or in other muscular efforts. Such movements, directly useful in certain simple situations, become linked up with similar but more complex situations in the course of the individual's experience.

Showing the teeth in scorn dates back, according to Darwin, to a prehuman stage of development, and is seen as a useful act in animals like the dog or gorilla that have large canine teeth. Baring the teeth in these animals is a preparation for using the teeth; and often it frightens the enemy away and makes actual attack unnecessary. This movement, Darwin urges, has survived in the race even after fighting with the teeth has mostly gone out. Many other expressive movements can be traced back in a similar way, though it must be admitted that the racial survivals are usually less convincing than those from the infancy of the individual.

Some expressive movements, like smiling, laughing, crying, sobbing and screaming, are certainly unlearned; and some are picked up by imitation. All such expressive movements become attached or conditioned to situations that originally could not arouse them. As the child grows up, he learns to *moderate* his expressions of anger and of glee, and he even learns to *conceal his emotions*. He is ridiculed for crying or showing fear; he gives offense by showing anger, or by crowing and strutting in pride. Politeness requires him to smile many times when he feels like scowling, and to exclaim in surprise at information that is perfectly trite. Thus social pressure trains him to keep his feelings to himself. At the same time, other people are always trying to discover how he does feel, and he himself scans the faces of other people in the attempt to *read their emotions*. There is a race between concealment of the emotions on one side and detection of the emotions on the other, like the race in warships between defensive armor and penetrating projectiles.

On the whole, expressive movements tend to become reduced as the individual grows older. But in make-believe play, on the stage, and in all kinds of acting, there is a development in the opposite direction, in the direction of *registering the emotions*. There is a language of the emotions, a language com-

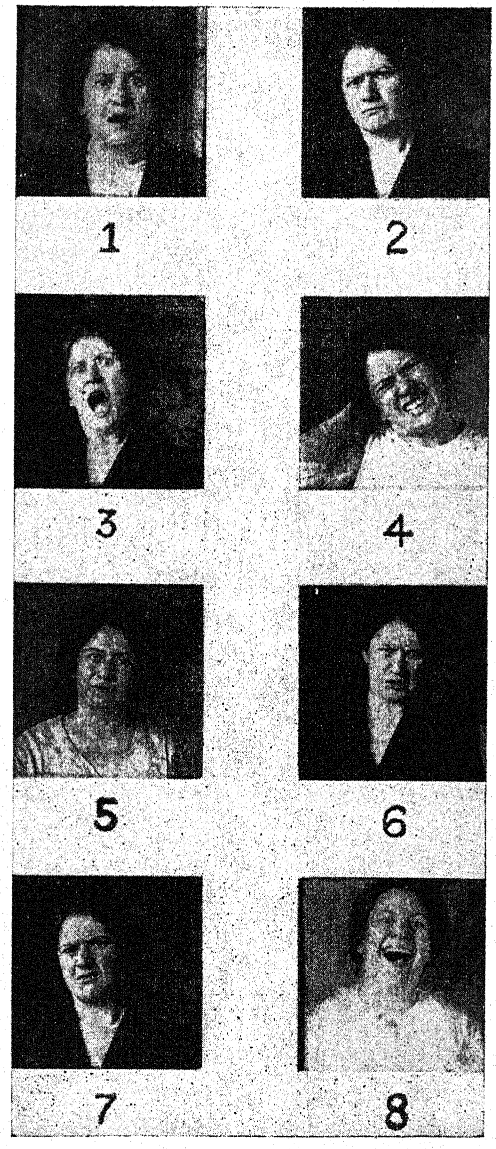


FIG. 19.—(From A. Feleky, *Feelings and Emotions,* 1924.) Facial poses for several emotions. Give each one a name that fits; and then select the best-fitting name from the following list, which includes the names most used in describing these particular poses: horror, laughter, sharp pain, pleasant feeling, surprise, disgust, determination, hate.

posed of gestures and postures, of exclamations and inflections and tones of the voice, of facial expressions. This language is no doubt based upon the unlearned expressive movements, but it has become standardized through long ages, and now is largely a matter of social custom and convention. The child finds this language in use, and appropriates it to some extent. Actors appropriate it to a large extent, and introduce their own individual improvements. The result is that this language of the emotions is much more expressive than the average adult's facial and vocal behavior during emotion. When the actor poses for an emotion, he makes full use of his face; but when the ordinary citizen is in an emotional state, his face may be a mask.

A favorite experiment on emotional expression is that of presenting photographs of facial poses for various emotions and asking your subjects to judge what emotion is intended by each pose. The experiment brings out the fact very clearly that the emotion cannot be recognized with certainty from a still picture alone. A smiling or laughing face may indeed give almost 100% of judgments of amusement or happiness, and a face intended to register pain may be so judged by as high as 85% of the judges. Surprise also can be successfully registered, and sometimes disgust. But fear is apt to be misinterpreted, unless it takes on the quality of horror; and anger has given only 30–40% of right judgments.

Photographs of the spontaneous, unposed expressions of ordinary people in the throes of emotion are not so easy to obtain. In the laboratory, restraint and self-consciousness militate against strong, unmixed emotions. More success has been obtained, strange as it may seem, in obtaining unpleasant than pleasant emotions in the laboratory.

In one experiment,[2] lasting over three hours, a series of situations was presented intended to arouse various emotions,

[2] C. Landis, *Journal of Comparative Psychology*, 1924, vol. 4, p. 447.

the series beginning with music and serious reading, and proceeding to startling, embarrassing, disgusting and painful situations, which became so drastic at the close as to cause weeping or vigorous angry language from nearly all the subjects. An attempt was made to analyze the facial expressions in terms of the different muscles concerned — those that raise or lower the brow, those that widen or narrow the eyes, those that "stick up" the nose, those that pull the lips upwards, outwards or downwards, etc. The object was to see whether there were any patterns of facial movement characteristic of the different emotions, but the result was negative. One individual differed from another in his characteristic expression; but the different situations failed to produce any strikingly different facial expressions. The eyes were apt to be narrowed in most of the situations, and the mouth was apt to be drawn into some sort of a smile or half smile. The face was smooth in the quiet situations at the start, and became somewhat ruffled and distorted in the more drastic situations late in the series; but there was a good deal of sameness in the facial expressions for the different drastic situations. One could tell from the photographs that something disturbing was going on, but not much more.

Vocal expression of emotion. The voice is perhaps more expressive than the face. When an accomplished singer tried to register an emotion by the mere tone of the voice, without words, inflection, or anything but tone, — and of course without any aid from the face, as the singer was screened in this experiment from the listeners, — she secured 75% of judgments in accordance with her intention when she registered anger or sorrow, about 50% with fear or pain, but almost zero when she tried to register surprise.[3] The speaking voice is more expressive than the singing voice, because it takes on more of the harsh quality, when needed, and especially because

[3] M. Sherman, *Journal of Experimental Psychology*, 1928, vol. 11, p. 495.

it is free to slide up and down the scale. The rising inflection in questioning, the falling inflection in finality, the circumflex inflection in sarcasm, are very expressive. The little word, "No," can be made to carry several meanings according to the inflection. Monotone goes with dull feeling, slides and jumps from low to high and from high to low go with excitement. The connection of excitement with loud and high-pitched voice is probably natural and unlearned, but how much more of the language of mere voice, as apart from speech, is unlearned and how much is dependent on social custom, we can only guess at the present time. When words, with their asso-

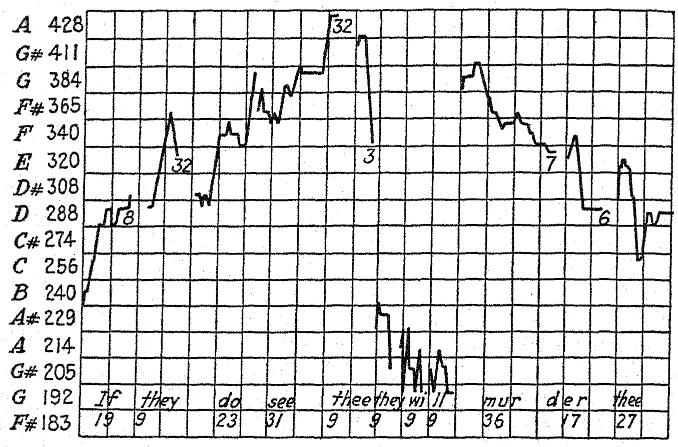


FIG. 20.— Inflection of the voice in emotional speaking. From G. M. Merry, *Psychological Monographs*, 1922, No. 140. Changes in the pitch of the voice measured from a phonograph record of Julia Marlowe's rendition of Portia's speech in "The Merchant of Venice."

ciated meanings, are added to vocal tones and inflections, the emotional expression becomes clear and finely shaded. Just the printed word, HORROR, in a newspaper headline, creates an emotional atmosphere.

Breathing and heart beat in emotion. Respiration and circulation are closely tied up with muscular activity, and thus

with the overt behavior of the individual. Excitement, attended as it is apt to be with muscular activity, is therefore attended also by increased breathing and heart action. But sometimes we see changes in breathing and heart beat that seem to be directly connected with the emotional state. A sudden starting stimulus may check breathing and first stop and then hasten the heart. Experiments [4] in which the rate of the pulse is recorded have shown an increase in heart rate with sensations of strong feeling-tone, whether the feeling was pleasant, as when chocolate was placed in the mouth, or unpleasant, as when quinine was tasted. There was no difference in the effect on the heart of pleasant and unpleasant stimuli; and, in general, there is little evidence of any characteristic difference of heart action in different emotions.

Breathing is apt to be shallow during a brief period of concentrated attention, and at the end of such a period there often appears a deep inspiration followed by a rather forcible expiration. This "sigh" makes up for the insufficient respiration of the preceding period. The sigh of grief or longing may arise in the same physiological manner, but we really know little about it. Considerable attention has been given of late to the *inspiration-expiration ratio,* or I/E ratio, as an indicator of emotional conditions. This ratio is obtained from a breathing record by dividing the time occupied by inspiration by the time of expiration. In regular breathing, inspiration lasts about half as long as expiration, so that the ratio is as 1 to 2, or .50. A singer inhales rapidly, when the music affords an opportunity, and pays out the breath gradually, thus lowering the I/E ratio to .20 or even lower. Something of the same kind, though less marked, occurs in talking, or even in whispering and silent talking. What will happen, then, if a person is doing mental multiplication under distraction? He is pretty sure to whisper the numbers to himself, in the effort to over-

[4] J. F. Shepard, *American Journal of Psychology,* 1906, vol. 17, p. 522.

come the distraction — just as we saw once before in a distraction experiment [5] — and so decrease his I/E ratio during the distraction. Now suppose that a person is giving false answers to a series of questions, trying to make his answers plausible. It is likely that there will be more intense inner speech during this process than if he were giving true and easy answers to the questions asked him. As a matter of fact, in this laboratory "lying," there is a decrease in the I/E ratio.

The *blood pressure,* or pressure in the arteries, depends on complex physiological factors, the chief of which are the output of blood from the heart, and the resistance offered by the small arteries to the passage of blood. In the lying experiment, the blood pressure rises, in perhaps 80% of the cases. Possibly this indicator of deception, as well as the I/E ratio, could be used in the police examination of suspects; and indeed the method has been used with some success, but must be regarded as still in an experimental stage. Probably there is no closer or more mysterious connection of lying with blood pressure than there is with breathing. The blood pressure is apt to rise in excitement, whether the excitement is brought on by the exigencies of making up a plausible story, by taking an intelligence test, or by getting a dose of strong electric shocks. In the prolonged emotional experiment described a few pages back, the blood pressure rose towards the close of the series of disturbing situations. It also rose momentarily in surprise.

Other signs of emotion. The cat's hair rises in fear or anger, and goose flesh in the human being is the same response, produced by tiny muscles under the control of the so-called "sympathetic" nerves. The pupil of the eye dilates in the same conditions and from the action of another related nerve. The sweat glands are similarly aroused, and in strong emotion the perspiration may stand in beads upon the skin. Even in momentary thrills of fear, surprise, embarrassment or expect-

[5] See above, page 264.

ancy, the sweat glands are stimulated to a slight degree by their nerves, and the result is a momentary change in the electrical condition of the skin, which can be registered by a galvanometer, and is called the *psychogalvanic reflex*. This electrical change is perhaps the most delicate indicator of emotion that the laboratory has yet produced.

THE ORGANIC STATE IN FEAR AND ANGER

Traditionally, the heart is the seat of the emotions, and this means, no doubt, that they are felt in the general region of the heart; and other ancient "seats," in the diaphragm or in the bowels, agree to the extent of pointing to the interior of the trunk as the general location where emotions are felt. There may be something in this primitive location of the emotions; there may be some internal disturbance in strong emotion that makes itself felt by obscure sensations.

Suppose we have a tame cat,[6] that knows us well, and after feeding her a good meal containing some substance that is opaque to the X-rays, suppose we place her on a table and pass X-rays through her body, so as to get a visible shadow of the stomach upon the plate of the X-ray machine. Well and good; the cat is contentedly digesting her meal, and the X-ray picture shows her stomach to be making rhythmical churning movements. In comes a fox terrier and barks fiercely at the cat, who shows the usual feline signs of anger; but she is held in position and her stomach kept under observation — when, to our surprise, the stomach movements abruptly cease, not to begin again till the dog has been gone for perhaps fifteen minutes. The churning movements of the intestine cease along with those of the stomach, and, as other experiments show, even the gastric juice stops flowing into the stomach. The whole business of digestion halts during the state of anger. So

[6] W. B. Cannon, *Bodily Changes in Pain, Hunger, Fear and Rage*, 2nd. ed., 1929.

anger is an organic state, without doubt. At least in cats — but the same is found to be true of man, and hence the excellent rule not to get angry on a full stomach.

Stomach-inhibition is not the only internal response during anger. The heart, so long regarded as the seat of the emotions, does beat more forcibly than usual; and the diaphragm, where the old Greeks located the emotions, does make extra-strong breathing movements. There are yet other and more curious changes that have recently been discovered by the physiologists.

Glandular responses during fear and anger. Thus far, we have been considering muscular responses, for the most part, but now we must turn our attention to the glands. The glands are often affected during emotion, as witness the shedding of tears in grief, sweating in anger, the dry mouth during fear due to inhibition of the salivary glands, and the stoppage of the gastric juice during anger, as just noted. These particular glands all pour out their secretions either upon the skin or upon the mucous membrane of the mouth, stomach, etc.; and such secretion is called "external" in distinction from the "internal secretion" of certain other glands which may be called the glands of internal secretion or the "endocrine glands." Internal secretions are discharged into the blood vessels, and carried by the blood to all parts of the body, and they have important effects on the activity of various organs. The internal secretions contain *hormones*, which are substances that increase or decrease the activity of different organs. A hormone is given off by an endocrine gland, and is carried by the blood stream to all the organs of the body, some of which it does not affect at all, while some it affects in the direction of greater activity, and some in the direction of less activity. The sex hormones have already been mentioned.[7]

The adrenals, two little glands located near the kidneys

[7] See above, page 249.

(whence their name, though their activity is distinct from that of the kidneys), have much to do with the organic state in fear and anger. Their hormone, called adrenalin, oozes slowly into the blood, in ordinary quiet conditions of the organisms, and has a valuable tonic effect upon the heart and muscles; in fact, without this hormone the organism cannot long continue to live. As soon as the organism embarks upon any strong muscular activity, the adrenal secretion is increased; and if the organism receives a stimulus that arouses fear or anger, again the adrenal secretion is increased. All the organs soon get a strong dose of adrenalin, and some of them are much affected by it. It hastens and strengthens the heart beat, it causes the big veins to squeeze the blood rapidly into the heart, and thus quickens the circulation. It stimulates the liver to release stored sugar rapidly into the blood, and thus the muscles are abundantly supplied with fuel, as well as with oxygen from the increased circulation (and respiration), and are able to work with great energy and with a minimum of fatigue.

While the adrenal hormone is thus stimulating the external muscles, it is having the opposite effect on the digestive organs; in fact it is having the effects just described as occurring there during anger. These inhibitory effects are started by the sympathetic nerves to the stomach, but are continued by the action of the adrenalin circulating through the stomach walls. The adrenal glands, in fact, are an adjunct to the sympathetic nerves. The gland is itself aroused by one of the sympathetic nerves, and its hormone affects the same organs, and in the same ways, as the sympathetic nerves. So, the sympathetic quickens the heart beat, adrenalin does the same; the sympathetic checks the stomach activity, adrenalin does the same. Both erect the hairs, both dilate the pupil, both produce sweating, both constrict the large veins and the small arteries and thus raise the blood pressure. Adrenalin, extracted from the

adrenals of slaughtered animals and used as a drug, has these same effects.

The organic state in fear and anger as a useful preparatory reaction. Though such an emotion as fear or anger seems like a disorganized condition, and is rather a handicap in most civilized activities, yet the organic state which has been described makes a first-class preparation for intense muscular activity, such as is demanded by physical flight or fighting. Rapid circulation and abundant fuel are positively useful, and the halting of digestion relieves the organism from dividing its energies between activities that can afford to wait and those that must be pushed now or never.

Essentially the same organic state occurs in strenuous muscular activity such as running a race. But in emotion the organic state may *precede* and prepare for the actual muscular exertion. The emotion need not be exactly fear or anger, for the same organic state has been found in football players before a game, and in students just before an examination. Probably the organic state was useful to the football players, and far from useful to the students. But in either case the emotion was scarcely fear or anger; it was described as being "all on edge" or "all keyed up." The state was one of *excitement,* and we can think of excitement as a state which occurs in actually running a race or playing a game or taking an examination, or in being ready for such an activity, and also in fear and anger. Anger is excitement with the addition of its own peculiar quality; and fear of the energetic sort is excitement plus its own peculiar quality. These peculiar qualities have to do with the overt activity for which the organism is set; for attack in anger, for escape in fear.

OTHER EMOTIONS AND OTHER ORGANIC STATES

In case of anger and fear, then, we find (1) a set of the organism towards a certain type of overt activity, and (2) an

organic state, which amounts to preparation for the overt activity. The set for the overt activity is felt by the individual as an impulse to attack or to escape, and the organic state is felt as excitement, and these two feelings are really one total feeling of anger or of fear.

A very pretty theory of the emotions is suggested by this case of anger and fear. Generalizing from this case, the theory would run that every emotion, objectively considered, consists of a set towards some type of overt activity plus an organic state preparatory for the overt activity; while subjectively the emotion is felt as an impulse towards a certain type of overt activity plus a mass of sensations produced by the organic state. The organic state might be much the same in several emotions, the difference between them lying in the different overt activities for which the organism was set. On the other hand, the set for overt activity would not of itself constitute an emotion, without the appropriate organic state.

The attentive reader will have noted a flaw in this pretty theory, even as applied to anger and fear, and we will come back to that matter later. But first let us consider whether the theory would hold good at all when tried out on other emotions.

It holds very well of sex attraction, and we need not review what was said in the last chapter on the sex hormones and organic states and their influence on the overt activity.

The theory holds equally well of hunger and appetite for food. There is the organic state of food-depletion, with stomach movements, and readiness of the salivary and gastric glands for active secretion, and there is the set of the organism for the overt behavior of food-getting and eating. Hunger is not usually called an emotion, but rather just an organic state or else a sensation, largely because the hunger pangs are localized as coming from the stomach region and are noted as indi-

cators of the fact of organic hunger. But if the hunger sensations are not very intense, they may not be definitely localized, and the individual may simply feel an appetite for food, which certainly should be classed as an emotion.

Fatigue from muscular activity is an organic state consisting largely in the accumulation in the muscles and in the blood of the waste products of muscular action, especially carbon dioxide and lactic acid. These substances, carried about by the blood, lower the activity of the organs through which they circulate. There may be local fatigue sensations in the exercised muscles and joints, and also a general diffuse weariness. There is clearly a set towards certain overt behavior, namely towards rest. The organic state is preparatory for rest, in the sense that it predisposes the organism for rest and unfits it for activity. Thus fatigue fits nicely into the framework of our tentative theory.

What may be the nature of the organic state in drowsiness we cannot say, but it seems clear that there is an organic state, and that it predisposes for sleep. If we allow ourselves to call sleep a (negative) form of overt behavior, then our scheme works all right here again. And it works with thirst as well, though the sensation of thirst is so well localized that we are not likely to call it an emotion, even though it certainly has emotional quality.

Emotions without known organic states. The theory we have been trying out seems to break down when we come to surprise, mirth, joy, grief, curiosity and some other emotions.

Surprise may perhaps be allied to fear. The psychogalvanic reflex, which is an indicator of the activity of the sympathetic nerves, is readily aroused by surprising stimuli. In surprise, the activity in progress is brought to a sudden halt, and the organism attends to something new and possibly dangerous that has entered the situation. The internal response is a slight beginning of the activity that goes with danger. The

overt activity is a slight beginning of escape. Surprise, then, is no great exception to our rule.

Mirth or amusement is the emotion that goes with laughter. Is there possibly an organic state here? All we can say is that laughter favors digestion, removes anger and counteracts fear — facts suggestive of some organic process opposed to that of anger and fear. Laughter is something of an enigma also because it produces no external results, except to be sure on other people.

Grief, if we may so call the emotion that goes with the baby's crying, is like mirth in having no known organic state, and in producing no external result — except the noise, of course. The noise here, as in the case of laughter, is of some importance when the presence of other people is taken into account.

Joy, though certainly akin to mirth, often occurs in situations that would not be called amusing. The joy or satisfaction of success occurs then when the overt activity is over, but the expression of joy has social effects, and it is even possible that the state of joy is organically favorable for the consolidation of what has been learned on the way to success, and is thus a factor of importance in the fixation of successful modes of response.[8] It would be going too far to assert that joy has no organic state and no important effects; it would be going just far enough to say that we do not know.

In *curiosity,* though the feeling is often strong enough and different from any of the other emotions, it would seem improbable that there is any special organic state. The overt activity consists in exploring what has aroused curiosity.

All in all, this survey of emotions without obvious organic states does not greatly weaken the theory which we wished to test. It is safe to say that there is always a set for some overt activity, even though the overt activity may not have any end in view. Almost always, there is the possibility of an organic

[8] Compare pages 89, 175.

state, but we should be overdoing the matter if we assumed an organic state, either specific or general, as part and parcel of every emotion.

Moods. A mood differs from an emotion in being less in intensity and longer in duration. While in an angry mood, a person may not be actually angry, but he is all ready to be made angry by the least provocation. Such a mood is often a hangover from an active emotion. Let a man be "all riled up" by something that has happened at the office, and he comes home quite ready to take it out on his wife and children. Slightly irritating performances of the children, that usually would not arouse an angry response from him, do so this evening because that thing at the office has made him cross. In the same way, a nervous or jumpy mood may follow a dangerous experience. From the fact that the cat, in the X-ray experiment, showed the internal state characteristic of fear and anger for quite a while after the irritating dog had gone away, we may conclude that angry and timorous moods are due, in part at least, to the persistence of the organic state set up in active emotion.

But what shall we say, then, of the persistence of a jovial mood after a good laugh, or of a happy mood after the joy of success? Perhaps there is an organic state, here too, that outlasts the active emotion.

Moods are however not always the after-effects of active emotional outbursts. Euphoria seems to be the mood that goes with excellent physical condition, and a depressed or "blue" mood may mean simply an unfavorable physical condition. Lassitude and the morning grouch may be simply the mood of one who is not yet fully awake.

DEVELOPMENT OF THE EMOTIONAL LIFE

Undoubtedly the emotional life of the child develops by maturation as well as by learning. Sex emotion, certainly,

cannot fully make its appearance till sex maturity brings the hormones and organic states that are essential to the emotion. The child's fears increase in number and scope in part because he grows to take account of a wider environment. In part, his fears are learned by the conditioned reflex process, already illustrated.[9] We have also mentioned the change that occurs in the way of moderating crying and other too energetic expressions of the emotions, and the substitution of laughter for fear or anger in many situations. The practical life of relation comes to dominate more and more over the emotional life, so that the child's behavior becomes less emotional as he grows older. If we were to construct a scale for emotional age, after the analogy of the Binet scale for mental age, our tests would certainly be in large part tests for *not* being afraid or angry or grieved or curious at things which regularly arouse those emotions in the younger child.

Sentiments. This term is used in psychology to refer to a complex emotional response or attitude towards some object or situation, a learned attitude built up in the course of experience with that object or situation. Often the "object" is a person. The baby's mother frequently gives him pleasure, but sometimes treats him sternly, and sometimes may be something of an enigma to him. Various emotional responses thus become attached to this same person, and the child's permanent attitude towards his mother becomes complex. The adult's sentiment towards a child is likely to combine tenderness and amusement. Hate is a sentiment, or complex permanent attitude towards a person, rather than any one emotion. If the hated person simply irritated you, without making you fear him as well, could you be said to hate him? Love, also, is more than any single emotion; it is complex, and built around the personal characteristics of the one loved. Patriotism is another instance of a complex, built-up, learned sentiment.

[9] See above, pages 159-160.

The higher emotions, esthetic, social, religious, are sentiments towards certain types of objects and are built up in the individual's experience, with much assistance from the social environment.

THEORY OF THE EMOTIONS

The task now before us is that of putting together the main facts that have emerged from our study of feeling and emotion, with the object of answering these two questions:

What is the difference between emotional behavior and unemotional?

What is the difference between one emotion and another?

The main facts that we have to work with are:

The overt activity and the set for overt activity, these differing from one emotion to another.

The organic state, present in some emotions, though perhaps not in all, this state not being the same for all emotions, nor yet different for every different emotion; it appears to be the same in anger, fear and other excited states, but something else in sex appetite or in food appetite or in fatigue.

The sensations, set up by the internal organic activity, by expressive movements, and by the overt activity, these sensations being taken as a mass, in feeling and emotion, and not as indicators of facts.

The greater or less dominance of the organism by the practical or brainy life of relation as against the more diffuse and undirected type of activity which occurs in strong feeling and emotion.

The James-Lange theory of the emotions. The American psychologist James, and the Danish psychologist Lange, independently of each other, put forward this theory about 1880, and it has ever since remained a great topic for discussion. According to the theory, a conscious emotion is simply a mass of sensations, coming from all over the body, especially from

the internal organs. The emotion is the *way the body feels* when in a disturbed organic state, and when going through the expressive and overt movements characteristic of the emotion. The stirred-up state of feeling is the complex sensation of the stirred-up bodily state. Just as the feeling of fatigue is a mass of fatigue sensations, so is anger or fear a mass of sensations.

James says, we do not tremble because we are afraid, but are afraid because we tremble. He means that the conscious state of fear is composed of the sensations of trembling (along with the sensations of other muscular and glandular responses). He means that the mere knowledge of present danger is not the feeling of fear and that the feeling only comes with the organic and overt response. As soon as these responses begin to take place, and to produce a mass of disturbed sensation, then the feeling of fear wells up. "Without the bodily states," James says, we might "see the bear, and judge it best to run, receive the insult, and deem it right to strike, but we should not actually *feel* afraid or angry." The "emotional warmth" of the experience comes from bodily sensations.

In appraising the value of this theory, we have to consider what theory it was intended to supplant. It was aimed at the common-sense theory which supposes that the sight of the bear arouses the feeling of fear, and that this feeling gives rise to the changed organic state, as well as to the overt movements of escape. Common-sense attempts no fine distinctions between the knowledge of danger, the impulse to escape, and the feelings of fear. James and Lange distinguished sharply between the knowledge of danger and the feeling of fear, but not between the feeling of fear and the impulse to escape. Probably if common-sense should attempt to use these distinctions, it would say that the knowledge of danger gave birth to the feeling of fear, and that in turn to the set for escape. But, as we have already said, some pages back, the set for escape is often cool and unemotional. Another significant fact

here is that we sometimes recoil from a sudden danger before experiencing any thrill of fear, and are frightened the next moment, after we have escaped. The set for escape is quicker than the feeling, and quicker also than the organic response. Therefore the common-sense theory is erroneous at one point anyway; the feeling of fear does not generate the set for escape. Probably the knowledge of danger gives rise directly to the set for escape, and both the feeling and the organic response come a little later, when they come at all. In strictness, the only question to which the James-Lange theory addresses itself is whether the feeling or the organic response comes first and gives rise to the other. This question is very difficult to settle, experimentally, and the evidence which has been collected often does not bear directly on the James-Lange theory at all. Yet this evidence is of great value for its bearing on a more complete theory of emotion.

Evidence for and against the James-Lange theory. The direct evidence that James hoped for was that which would be afforded by human subjects who had lost internal sensation; according to the theory, they should then have lost emotional feeling as well. Evidence of this sort has been slow in coming in. A few persons who turned up at nerve clinics, complaining that they no longer had any feelings or emotions, were found to have lost internal bodily sensation. These cases support the theory, but other cases have given the opposite result, so that the whole line of evidence has led to no conclusion.

Sherrington attempted a physiological examination of this question.[10] He took a dog that had been in the laboratory for months, and that showed a markedly emotional temperament, affectionate toward some individuals and hostile to others, and performed certain nerve-cutting operations which deprived the animal of nearly all sensation from the interior of the trunk. But this loss of sensation produced no obvious change in the

[10] *Integrative Action of the Nervous System,* 1906, p. 259.

dog's emotional behavior. "Her anger, her joy, her disgust, and when provocation arose, her fear, remained as evident as ever." A visitor who had previously awakened her anger was again received with signs of rage — wide-open eyes, dilated pupils, vicious growls — while the attendant who fed her was received with all signs of joy.

This experiment certainly proves that the overt behavior and expressive movements of emotion do not depend upon sensations from the interior of the trunk. Of course, it is impossible to say, absolutely, what the dog *felt*. It might be argued that the dog went through the external movements with no emotional feeling. But so strained an interpretation of the dog's behavior could only be justified by very strong evidence from some other source of the truth of the James-Lange theory.

Another physiological experiment [11] carries us a step further. By cutting the sympathetic nerves, the whole organic state dependent on those nerves was made impossible in a cat, and still the cat continued for months to show, under appropriate circumstances, the overt behavior and expressive movements of anger — growling, hissing, showing the teeth, drawing back the ears, lifting the front leg to strike. We see, then, not only that the *sensations* from the organic state are unnecessary for giving rise to the external behavior of anger, but further that the organic state itself is unnecessary. The organic state, if set up, strengthens and prolongs the external movements, but the external part of the emotional outburst can occur without the organic state.

In this last experiment, the organic state is artificially removed, and the overt behavior and expressive movements are still aroused by the usual stimulus. What would happen, on the other hand, if the organic state should be artificially produced, without any external stimulus for fear or anger? This

[11] W. B. Cannon, in Reymert's *Feelings and Emotions: The Wittenberg Symposium*, 1928, p. 262.

experiment has been tried, by giving adrenalin to human subjects — under medical supervision, as an overdose has bad effects. Some of the subjects, after taking the adrenalin, said they felt "on edge," as before a game or race in which they were to participate. Some of them reported that they "felt as if they were afraid, though of course they were not really afraid," or "as if they were awaiting a great joy," or "as if they were going to weep without knowing why." The feelings produced by the adrenalin were all "as if." But complete emotions were specially easy to arouse while the subjects were adrenalized. The hormone, though not actually producing emotion, had put them into an emotional mood.[12]

We see, from these experiments, that an organic state may favor a certain emotion, or predispose to that emotion, though it is not essential to the emotion. Under ordinary conditions, a certain organic state is present in fear and anger, and contributes towards frightened or angry behavior and feeling. As the same organic state occurs in both fear and anger, the difference between these two emotions must lie in the set for escape in one and for attack in the other — as was said before. But this same organic state occurs in strenuous muscular activity such as running a race, though the runner is neither frightened nor angry, but may be quite cool and calculating. He may keep his head and still have the physical benefit of the organic state. The sprinter has the same organic state as a man who is fleeing in terror. He gets the same sensations from the internal organs and from the running muscles. He ought, then, according to the James-Lange theory, to have the same frightened feeling. The theory certainly breaks down here.

The difference between emotional and unemotional activity does not lie in the presence or absence of an organic state, nor in the presence or absence of a certain overt activity, nor in the

[12] These experiments, by Cannon and by Maranon, are described in the *American Journal of Psychology*, 1927, vol. 39, p. 106.

presence or absence of certain sensations. It depends on the degree to which the individual keeps his head, that is, on the degree to which his brainy life of relation dominates his whole activity. If he completely loses his head, his sensations become a diffuse mass of feeling, and his set for overt activity becomes a blind struggle. If he only partially loses his head, he throws himself with abandon into overt activity, while still remaining somewhat observant, his movements are vigorous or even rather violent, and his sensations are mostly a feeling-mass. If he completely keeps his head and remains cool and calculating in the midst of his activity, he is able to take advantage of all the breaks of luck, but his movements may lack something in energy, and he loses the relish of the experience.

Under what conditions is the individual likely to lose his head? When does the brainy life of relation relax its grip and leave emotion unfettered? When the situation is unclear, so that observation gets no facts to guide action. When the situation cannot be handled successfully because of lack of skill. When the goal cannot be reached quickly enough. When the goal has been reached, and there is nothing to do but to burst forth in joy. When the organic state is strong and lively, like a horse that is all warmed up and hard to control. During fever or intoxication, when the highest part of the brain, concerned in the "brainy life of relation," is partly thrown out of function and ceases to dominate the lower parts of the brain that, left to themselves, carry out the blinder and more impulsive life of emotion. This last statement will have more meaning when we come to study the brain in a later chapter.

EXERCISES

1. How is feeling less "brainy" than the life of relation?

2. If you were giving a talk on motivation, how would you bring in the emotions?

3. Does the author seem to come through the chapter with any

definite theory of the emotions? What becomes of his "pretty theory" of page 299, and of the James-Lange theory?

4. The common-sense theory, applied to the case of laughter, would say that the joke made us feel amused, and that the feeling made us laugh. What would the other theories say?

5. Show that a still picture gives a very incomplete idea of the way a person registers anger, in case he wishes to make it very clear that he is angry.

6. Why should a brisk walk dissipate an emotional state? What other indirect means can be used to control or eliminate emotions?

7. Distinguish by definition and example: feelings, emotions, sentiments, impulses.

8. Would you be inclined to class emotions and organic states together, or to insist on a distinction between them?

9. As you have observed and experienced fear and anger, how would you compare the two states?

10. Discuss this question: Can we properly speak of one individual as being more emotional than another, in general, or must we specify the emotion to which each individual is more addicted?

11. From his studies of babies, Watson concluded that fear, rage and love were the only primary, unlearned emotions. What else should be added, if no distinction is made between the emotions and other organic states?

REFERENCES

For the James-Lange theory, see their original articles reprinted in C. G. Lange and W. James, *The Emotions*, 1922.

For the organic states, and the bearing of physiological evidence on the theory of emotions, see W. B. Cannon, *Bodily Changes in Pain, Hunger, Fear and Rage*, 2d ed., 1929.

For numerous papers by various authors on the subject of emotion, see M. L. Reymert, *Feelings and Emotions*, 1928.

For the psychiatric angle on emotion, an important angle, since emotional disturbances play so large a part in mental disorders, see J. T. McCurdy, *The Psychology of Emotion*, 1925.

CHAPTER VIII

SENSATION

THE SENSES AND THE FUNDAMENTAL DATA FURNISHED BY THEM

In the first chapter, we proposed to arrange our material as follows: first general topics, then analysis into special activities, then physiological analysis, and finally synthesis. We are now in the midst of our study of special activities. Feeling and emotion count as special activities of the organism. Now we come to the activities that give knowledge, that make the organism acquainted with the world, and enable it to deal intelligently with objects.

Evidently the ways in which the individual finds out facts are an important part of psychology. Broadly, he discovers by observing with his senses, and by thinking — or by both observing and thinking together. We propose to devote three chapters to the process of finding out the facts. One chapter on the senses, which furnish the data, one chapter on the observation of facts presented to the senses, and one chapter on thought processes.

Since the sense organs, like other organs of the body, are studied in physiology, the student is likely to feel that they have no place in psychology. It is true that the detailed structure and action of the sense organs are matters for sense physiology, but psychology is certainly concerned with the utilization of sense data, and needs therefore to know what those data are. As the student advances into the present chapter, he will find that there is much psychology bound up with the study of the senses.

"Sensation" is another of those nouns that are properly verbs. To sense is to see, or hear, or smell, etc. The noun "sensation" is used in two ways: first as a general name for all this type of activity and second as a name for any particular action of this sort. The visual sensations, in this latter usage, are all the particular actions that come under the name of seeing. Seeing blue is a sensation, and so is hearing a tone, or getting the bitter taste, or feeling cold on the skin.

Sensation is unlearned. The senses develop by maturation, just as the muscles do, and when the structure is sufficiently developed, activity ensues on stimulation. The child does not learn to see or hear, though he must learn the meaning of what he sees or hears. He gets sensation as soon as his senses are stimulated, but recognition of objects and facts comes with experience. Hold an orange before his open eyes, and he sees, but the first time he doesn't see *an orange*. The adult sees an object, where the baby has only sensation. "Pure sensation," free from all recognition, can scarcely occur except in the very young baby, for recognition is about the easiest of the learned accomplishments, and traces of it can be seen in the behavior of babies only a few days old.

Sensation is a response; it does not come to us, but is aroused in us by the stimulus. It is the stimulus that comes to us, and the sensation is our own act, aroused by the stimulus. Sensation means the activity of the receiving organ (or sense organ), of the sensory nerves, and of certain parts of the brain, called the sensory areas. Without the brain response, there is apparently no conscious sensation, so that the activity of the sense organ and sensory nerve is preliminary to the sensation proper. Sensation may be called the first response of the brain to the external stimulus. It is usually only the first in a series of brain responses, the others consisting in the recognition of the object and the utilization of the information so acquired.

THE SENSE ORGANS

What is essential in a sense organ is that it shall be sensitive to some form of stimulus. The most primitive animals, the protozoa, though sensitive to various stimuli, are sensitive all over, rather than in certain spots. They respond to mechanical stimuli, as contact or jarring, to certain chemical stimuli, to thermic stimuli (heat or cold), to electrical stimuli, and to light. They have no special light-sensitive spot, but respond to light no matter where it strikes them.

In the development of the metazoa, or multicellular animals, specialization has occurred, some parts of the body becoming muscles with the primitive motility much developed, some parts becoming digestive organs, some parts conductors (the nerves) and some parts becoming specialized receptors or sense organs. A sense organ is a portion of the body that has very high sensitivity to some particular kind of stimulus. One sense organ is highly sensitive to one stimulus, and another to another stimulus. The eye responds to very minute amounts of energy in the form of light, but not in other forms; the ear responds to very minute amounts of energy in the form of sound vibrations, the nose to very minute quantities of energy in certain chemical forms.

Each sense organ is like a registering or receiving instrument, an indicator of some force or agency, just as the thermometer is an indicator of temperature. The sense organs are, on the whole, highly sensitive indicators. The real sensitive part of each sense organ is not visible from outside, but lies in the depth of the organ. The sensitive receiving surface for smell lies well back inside the nose, and the sensitive receiver for sound is not the ear that we see, but the "inner ear," embedded in the bone of the side of the head. And so with the rest. Now, we may well ask, how is the great sensitivity brought about? In the first place, each sense organ

has a *sensory nerve,* connecting it with the nerve centers and so, indirectly, with all parts of the organism. Without such a connection the sense organ, however sensitive it might be, would have no influence on the activities of the organism. The sensory nerve breaks up, within the sense organ, into an immense number of very *fine branches,* and the sensitivity of the sense organ is due in part to the fineness of these nerve filaments. In the eye, the ear, the nose and the mouth there are also special *sense cells,* each type of sense cell being tuned to the type of stimulus it has to receive. Besides these sensitive structures, there is accessory apparatus connected with most of the senses, which brings the stimulus effectively to the nerve and sense cells. So, the external ear, which we see, is accessory apparatus, serving to convey sound waves into the bone where the auditory sense cells are located.

Since a sense organ is a receiving instrument, it is also called a *receptor,* and a useful classification of the senses divides them into the exteroceptors, the interoceptors, and the proprioceptors. The exteroceptors receive stimuli from outside the organism, the interoceptors from the internal surface of the organism, i.e., from the surface of the mouth, throat, gullet, stomach, intestines, and lungs, while the proprioceptors are located in the proper substance of the body, i.e., in the muscles, tendons, joints, bones, etc., and are stimulated by movements of these parts. Of the exteroceptors, the eye, ear and nose are singled out as *distance receptors,* because they receive stimuli from sources that are not in contact with the organism. The distance receptors make the organism responsive to what is going on at a greater or less distance, and enable the organism to adjust itself to a wider environment.

The excellence of a receptor depends (1) on its being tuned to a certain kind of stimulus, so that it is *selective* rather than responding indifferently to everything that happens, (2)

on its being very *sensitive* to its particular kind of stimulus, so as to respond to faint stimuli, (3) on its responding differently to different *intensities* of the stimulus, and (4) on its responding differently to different qualities or *varieties* of the stimulus. For example, the sense of smell is selective in that it responds to odors and not also to sounds entering the nose — which would be confusing; it is sensitive in that it indicates the presence of incredibly small quantities of an odorous substance in the air; it responds differently to faint and strong odors, so as to indicate how strong the odor is; and it responds differently, i.e., gives different smells, according to what the odorous substance is. Few man-made instruments can vie with the nose in these respects, — or with the eye and ear.

ELEMENTARY SENSATIONS, BLENDS AND PATTERNS

Within each sense, we find different qualities of sensation, corresponding to the different varieties of the stimulus. Consider the sense of sight, for example. Disregard the numerous objects that we see — flowers, stones, people and the rest — and consider only the various colors and shades. Each shade or color is a different quality of sensation, a different response of the sense of sight to some variety of light. But many of these color responses may be compound responses, as the sensation of orange color may be a compound of elementary red and yellow sensations, and purple a compound of red and blue. The number of elementary color sensations may be small. Here, then, we have a problem that has occupied the students of sensation.

There are two kinds of compound sensations, blends and patterns. In a *blend*, the elements are fused together into a characteristic total quality. Each element contributes to the total quality, and at the same time gives up some of its own peculiar quality. The color orange, for example, a blend of

red and yellow, partakes of the red and of the yellow, without having the full quality of either, and has its own quality which must be seen to be appreciated. In a *pattern,* the component parts are spread out in space or in time, and can be separately noticed. A mosaic of red and yellow stones would be an example. The red and the yellow can be seen separately, each with its own full quality. Yet the pattern, like the blend, has the effect of a unit. A spatial pattern has a characteristic shape and arrangement, and a temporal pattern a characteristic progression. A rhythm of drum beats, or a tune of notes, is a good example of a pattern.

We shall find much to say of patterns in the following chapter on observation, but the analysis of blends belongs under the study of sensation, as a part of the search for the elementary qualities of each sense. Along with the search for these elementary responses of each sense goes the search for the stimulus that arouses each response. Our task will now be to ask these questions regarding each sense, and also to examine some of the peculiarities of each sense. The whole subject of sensation is extremely extensive and full of detail, but we shall here cite but a few salient facts.

THE SKIN SENSES

Rough and smooth, hard and soft, moist and dry, hot and cold, itching, tickling, pricking and stinging are skin sensations; but some of them are certainly compounds. The way to isolate the elements is to explore the skin, point by point, with weak stimuli. For a cool stimulus, a pencil point at room temperature will serve for a moment. Passing it lightly along the skin, we get at most points merely a sensation of contact, but at certain points there is a clear cold sensation. Within any half-inch square on the back of the hand, several of these *cold spots* can be found, and painstaking work, with adequate apparatus and procedure, shows them to be permanent. Simi-

larly, *warmth spots* are located by using a stimulus a few degrees warmer than the skin. If a sharp point is pressed moderately against the skin, it gives at certain places a small, sharp pain. These are the *pain spots*. Finally, if the skin is explored with a hair of just the right stiffness, nothing at all is felt in most places, but at some points there is a definite sensation of touch or contact; and these are the *touch spots*.

As no further varieties of sensory spots are found, touch, warmth, cold and pain are believed to be the only elementary cutaneous sensations. Itch, stinging and aching seem to be variations of pain. Tickle seems to be a variety of touch. Smooth and rough are patterns of touch. Moist is a blend of touch and cold. Hard and soft combine touch from the skin with resistance encountered by the muscles and detected by the muscle sense.

The hot sensation is interesting and curious. It is not simply a high degree of the warmth sensation, but is a combination of warmth and cold sensations. When a single cold spot is stimulated with a temperature of 100–110° Fahrenheit, it responds with its regular sensations of cold. This cold sensation from a warm stimulus is called the "paradoxical cold sensation." The same temperature applied to a warmth spot gives the sensation of warmth. Now apply this same temperature simultaneously to both a warmth spot and a cold spot, located near together on the skin, and you get the sensation of heat. Or, you can get the hot sensation by simultaneously applying a cold stimulus to the cold spot and a warm stimulus to the warmth spot.[1] If the temperature applied to the skin is quite high, the pain spots also respond, and the pain sensation dominates. A very cold object excites also the pain spots and gives a sensation scarcely distinguishable from that of burning heat.

[1] See Burnett and Dallenbach, *American Journal of Psychology*, 1927, vol. 38, p. 418.

The elementary stimuli of the skin senses. The question is, exactly how the skin is acted on to give each elementary sensation. In the case of touch, the exact stimulus is a bending of the skin, either in or out, at any touch spot, or at many touch spots at once. The stimulus that gives pain may be mechanical (as a needle prick), or thermal (heat or cold), or chemical (as a drop of acid), or electrical; but in any case it must be strong enough to injure or almost injure the skin. The pain receptors, then, are not highly sensitive, but require a fairly strong stimulus; their use is to detect the presence of stimuli that threaten injury.

Temperature stimuli require more discussion. The internal body temperature is steady, in health, at about 98° Fahrenheit, but the skin, exposed to an external temperature of perhaps 70°, is cooled below body temperature, usually to about 85–90°, and is "adapted" to its own temperature, which seems neither warm nor cool, because neither the warmth nor the cold spots are aroused. Suppose the skin temperature at a certain time to be 90°, with no sensation of either warmth or cold, and let a metal object, or other good conductor of heat, be laid upon the skin. If the metal object is warmer than the skin, it will raise the skin temperature where it lies; if the metal object is cooler than the skin, it will lower the skin temperature. If the stimulus is as much as a single degree above or below the skin temperature, it will give a sensation of warm or cool. Regarding the organism as a thermometer, we may say that its zero lies at skin temperature, and that its sensitiveness is pretty good for temperatures just above or below its zero.

This psychological zero shifts up and down according to the temperature of the skin. Immerse the hand for five minutes in water at any temperature between about 60° and 100° F., and you change the skin temperature and the zero point to correspond. Objects a degree or two warmer or cooler

than the new zero will give the warm or cool sensation. Beyond the limits mentioned, the temperature sense cannot fully adapt itself.

There is an old and striking demonstration of temperature sense adaptation — a rougher form of the experiment just

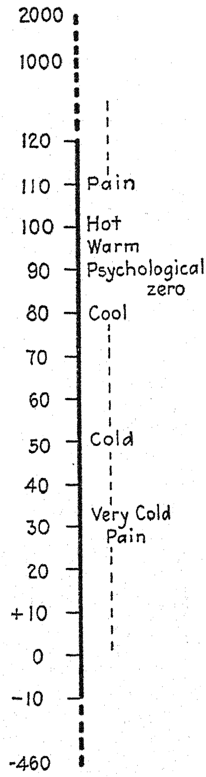


FIG. 21. — The psychological thermometer.

described. Take three bowls of water, one just about skin temperature and seeming neither warm nor cold, one definitely hot and one definitely cold. Hold one hand in the hot water and the other in the cold, for half a minute, and then plunge them both into the medium water; and you will find the

latter to feel warm to the cold-adapted hand and cold to the warm-adapted.

The organism as a thermometer gives more than the simple fact that an object is above or below skin temperature. With colder and colder objects, it gives increasing intensities of the cold sensation, till finally the pain sense is aroused. With objects above the psychological zero, it gives increasing intensities of the warmth sensation, then adds paradoxical cold to give the sensation of heat, and finally, at about 110–115° F., the pain sense is aroused again. The whole range of temperatures, from cold pain to heat pain, is of course only a small fraction of the range of external temperatures.

The skin receptors. Now the skin itself is not sensitive; there must be sense organs in the skin. Innumerable sensory nerve fibers grow out from the nerve centers into the skin, where each one divides into many fine branches. Not in the uppermost, horny layer of the skin, but just a little way in, is a perfect forest of fine nerve branches. There are no detectable "spots" in this forest of nerve endings. This experiment has been tried:[2] Cold spots and warmth spots have been carefully located, and then the bits of skin containing them have been cut out, stained, and examined in the microscope, to see what receptors lay under the spots. What was found was the forest of fine nerve endings, with nothing to distinguish the warmth from the cold spots or either of them from the adjacent skin.

The cat's whiskers are no doubt excellent touch organs, and human hairs, short or long, function in the same way. The hairs themselves are not sensitive, but they extend down into the forest of nerve ends in the skin and, when touched on the outside, act as little levers in stimulating the nerve ends. They are accessory apparatus to the touch receptors.

[2] See K. M. Dallenbach, *American Journal of Psychology,* 1927, vol. 39, p. 402; and C. R. Pendleton, same *Journal,* 1928, vol. 40, p. 353.

On hairless surfaces, especially the palms, some of the sensory nerve fibers terminate in little cones of tissue within the skin, and these "touch corpuscles" are believed to be touch receptors. On the surface of the eyeball, in the mucous membrane of the mouth and nose, and in many internal parts of the body, are found other corpuscles or end-bulbs, minute round or oval bodies, with a sensory nerve fiber terminating

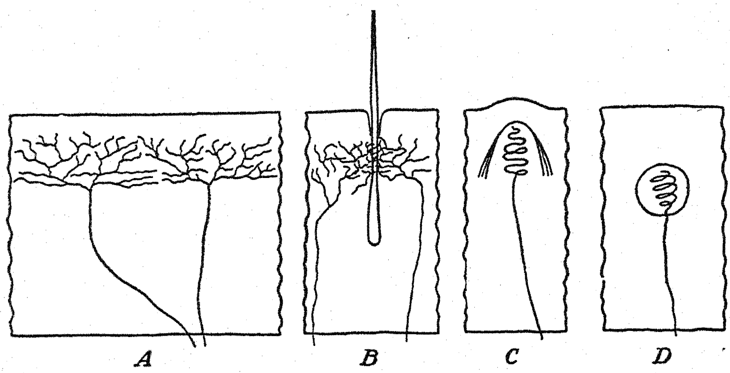


FIG. 22. — Diagrammatic views of skin receptors:
A, the most common type of skin receptor, present everywhere.
B, the hair receptor.
C, A touch corpuscle, from the finger tip.
D, An end-bulb, from the mucous membrane. There are several other varieties of end-bulbs found in the mucous membrane, in the surface of the eye-ball, in the subcutaneous tissue, etc.

in each of them. These are certainly receptors, and some of them seem to serve the temperature sense, but the function of most of them is not yet clear.

It should be noted that sensory nerve endings are present in the subcutaneous tissue, and that deep pressure and dull pain can be felt there even when the skin is anesthetized. Cutaneous sensation extends into the mouth and nose, and the tip of the tongue is a keen touch organ, but on the whole these extensions of the skin senses are less keen than the skin itself. As everybody knows, the skin is much keener in some parts

than in others, and the four skin senses vary independently from place to place, one place being especially sensitive to cold, another to warmth, another to touch stimuli.

THE MUSCLE SENSE

The muscle sense was the "sixth sense," so bitterly objected to in the middle of the nineteenth century by those who maintained that the five senses that were good enough for our fathers ought to be good enough for us, too. The question was whether the sense of touch did not account for all sensations of bodily movement. It was shown that there must be something besides the skin sense, because weights were better distinguished when "hefted" in the hand than when simply laid in the motionless palm; and it was shown that loss of skin sensation in an arm or leg interfered much less with the coördinated movements of the limb than did the loss of all the sensory nerves to the limb. Later, the crucial fact was established that sense organs (the "muscle spindles") existed in the muscles and were connected with sensory nerve fibers; and that other sense organs existed in the tendons and about the joints. This sense is muscle, tendon and joint sense rather than simply muscle sense. It is sometimes called the *kinesthetic* sense, from the Greek words meaning "sense of movement." Its receptors are "proprioceptors," being stimulated by activities of the body itself.

The muscle sense is stimulated by movements and positions of the various members, and also by external resistance encountered in making any movement. Thus it is not exclusively proprioceptive after all; in fact, it furnishes very important information regarding the weight of objects, their firmness or looseness, hardness or softness, and it undoubtedly has much to do with the child's adjustment to a world dominated by the pull of gravity. The muscle sense and the sense of touch work together in exploring the world

by the mouth or the hand or by any sort of bodily movement.

The muscle sense is important in either reflex or voluntary movement. Without it, when you wanted to start a movement, you would have little or no indication of the existing position of the limbs; and when the movement was on the

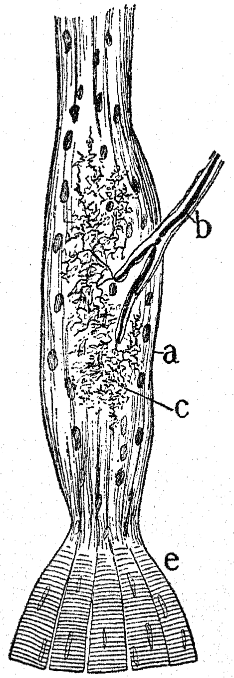


FIG. 23. — (From Cajal.) A "tendon spindle," very similar to the muscle spindle spoken of in the text, but found at the tendinous end of a muscle instead of embedded in the muscle substance itself. "a" indicates the tendon, and "e" the muscle fibers; "b" is a nerve fiber, and "c" its end-brush about the spindle. Let the tendon become taut in muscular contraction, and the fine branches of the nerve fiber will be squeezed and so stimulated.

way, you would have little indication of how far it had progressed and would not know when to stop it. Locomotor

ataxia, a disease characterized by unsteady posture and poor control of movement, is primarily a disease of the muscle sense nerves.

ORGANIC SENSATION

The term "organic sensation" is used to cover a variety of sensations from the internal organs, such as hunger, thirst, nausea, suffocation and less definite bodily sensations that color the emotional tone of any moment, contributing to "euphoria" and also to disagreeable states of mind. Hunger is a sensation aroused by the rubbing together of the stomach walls when the stomach, being ready for food, begins its churning movements. Careful studies of sensations from the internal organs reveal astonishingly little of sensation arising there, but there can be little doubt that the sensations just listed really arise where they seem to arise, in the interior of the trunk.

Little has been done to determine the elementary sensations in this field; probably the organic sensations that every one is familiar with are blends rather than elements.

THE SENSE OF TASTE

Analysis has been as successful in the sense of taste as in cutaneous sensation. Ordinarily we speak of an unlimited number of tastes, every article of food having its own characteristic taste. Now the interior of the mouth possesses the four skin senses in addition to taste, and many tastes are in part composed of touch, warmth, cold or pain. A biting taste is a compound of pain with taste proper, and a smooth taste is partly touch. The consistency of the food, soft, tough, brittle, gummy also contributes, by way of the muscle sense, to the total "taste." In addition to all these sensations from

the mouth, the flavor of the food consists largely of odor. Food in the mouth stimulates the sense of smell along with that of taste, the odor of the food reaching the olfactory organ by way of the throat and the rear passage to the nose. If the nose is held so as to prevent all circulation of air through it, most of the "tastes" of foods vanish; coffee and quinine then taste alike, the only *taste* of each being bitter, and apple juice cannot be distinguished from onion juice.

But when the nose is excluded, and when cutaneous and muscular sensations are deducted, there still remain a few genuine tastes. These are sweet, sour, bitter and salty — and apparently no more. These four are the elementary taste sensations, all others being compounds.

Analysis of tastes, like that of skin sensations, is greatly assisted by the fact that the different sensations are aroused by stimulation of different spots. The papillae or little protuberances on the surface of the tongue contain the taste receptors, and correspond to the spots of the skin, with this difference, that each papilla does not give a single taste sensation. Some of them, however, give only two or three of the four elementary tastes; and the bitter taste is got principally from the rear of the tongue, sweet from the tip, sour from the sides, and salty from both tip and sides. A sweetened bitter solution tastes sweet when applied with a little brush to the tip of the tongue, and bitter when applied to the rear of the tongue.

The actual taste receptors, called taste buds, are located not on the surface of the tongue, but in little pits which extend down from the surface. The taste buds are bunches of sense cells, each cell having a slender tip that projects into the pit, where it is exposed to the sugar or salt or other tasting substance, present in the mouth. The sense cell, being thus aroused to activity, arouses in turn the fine branches of the

sensory nerve fiber which twines around the base of the cell. Thus a nerve current is started along the sensory nerve to the brain.

The stimulus to the sense of taste is of a chemical nature. The tasteable substances must be in solution in order to penetrate the pits and reach the sensitive tips of the taste cells. If the upper surface of the tongue is first dried, a dry lump of sugar or salt laid on it gives no sensation of taste until a

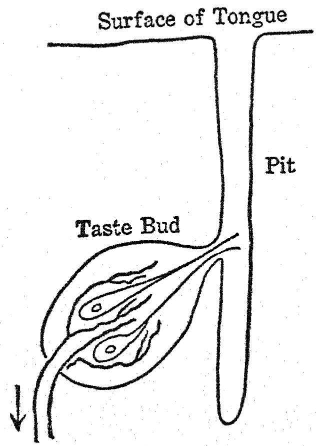


FIG. 24. — Diagram of the taste receptors. Within the "taste bud" are seen two sense cells, and around the base of these cells coil the fibers of the nerve that leads to the brain.

little saliva has accumulated and dissolved some of the substance.

Exactly what the chemical agent is that produces a given taste sensation is a problem of some difficulty. Many different substances give the sensation of bitter, and the question is, what there is common to all these substances. The sweet taste is aroused not only by sugar, but by glycerine, saccharine, and even "sugar of lead" (lead acetate). The sour taste is aroused by most acids, but not by all, and also by

some substances that are not chemically acids. The chemistry of taste stimuli is not as yet fully understood.

Though there is this uncertainty regarding the stimulus, on the whole the sense of taste affords a fine example of success achieved by experimental methods in the analysis of complex sensations. At the same time it affords a fine example of the fusion of different sensations into characteristic *blends*. The numerous "tastes" of every-day life, though found on analysis to be compounded of taste, smell, touch, pain, temperature and muscle sensations, have the effect of units. The taste of lemonade, for example, compounded of sweet, sour, cold and lemon odor, has the effect of a single characteristic sensation. It can be analyzed, but it ordinarily appears as a unit.

THE SENSE OF SMELL

The great variety of odors has proved very difficult to analyze into any definite elementary sensations. The olfactory receptors are so secluded in their position, in a little alcove way back in the nose, that they cannot be explored as the skin and tongue have been. The receptors are sense cells, much like those of taste, with fine tips reaching to the surface of the mucous membrane lining the nasal cavity and so exposed to chemical stimulation by odorous substances inhaled in the air.

Since we cannot apply stimuli to the separate receptors, about all that can be done in the way of analysis is to assemble a complete assortment of odors, and become thoroughly acquainted with their similarities and differences. Some are much alike, some very different. Series can be arranged, grading off from one salient odor through intermediates to another salient odor. Recent work indicates about six salient odors, but whether these are true elements or not is still uncertain. The following is Henning's classification, or list of the salient odors:

1. Spicy, found in pepper, cloves, nutmeg, etc.
2. Flowery, found in heliotrope, etc.
3. Fruity, found in apple, orange oil, vinegar, etc.
4. Resinous, found in turpentine, pine needles, etc.
5. Foul, found in hydrogen sulphide, etc.
6. Scorched, found in tarry substances.

These being the outstanding odors, there are many intermediates. The odor of roasted coffee is intermediate between

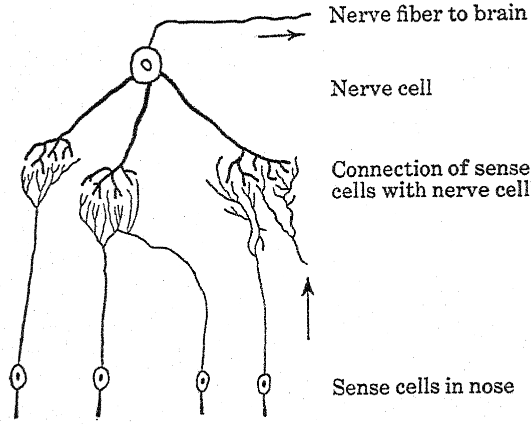


FIG. 25. — The olfactory sense cells and their brain connections.

resinous and scorched, that of peppermint between fruity and spicy, etc.

The stimulus of the sense of smell is undoubtedly chemical, but the chemistry of odors is not well understood at present. It is an extremely sensitive sense, responding to very small quantities of certain substances diffused in the air. Other substances arouse no olfactory response at all. Smell is important in connection with food and filth, and pleasant and unpleasant odors add spice to life. Some animals, such as the dog, seem to make much more use than we do of this sense in exploring the world; but it is probable that we use it more than we suspect.

THE SENSE OF HEARING

Sound is physically a wave motion or vibration in the air, or in any conducting medium. In the air, it consists in a slight back and forth motion of the air particles, a motion usually too slight to be felt by the sense of touch. The ear is much more sensitive, by virtue of its sense cells and accessory apparatus.

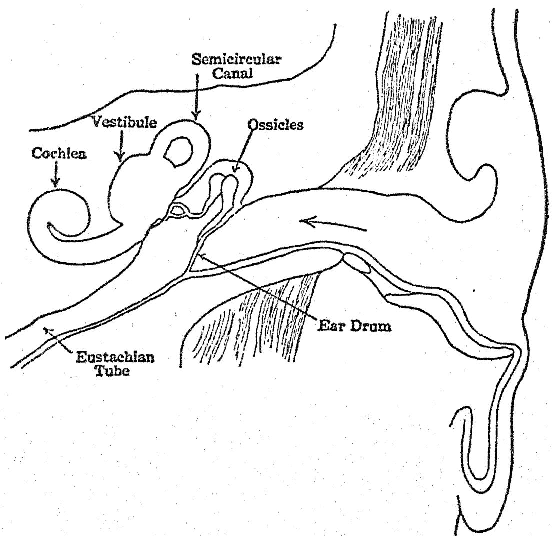


FIG. 26. — Diagram to show the parts of the ear, and the path of the sound waves from the outer through the middle into the inner ear. They start in as indicated by the arrow, and pass successively through the tympanic membrane, the ossicles, the vestibule, the cochlea. The middle ear is filled with air, which comes in by way of the throat and the Eustachian tube.

The sound-receiving apparatus of the ear. We speak of the outer, middle, and inner ear. The outer ear is a collector, the middle ear a transformer, and the inner ear the sensitive receptor. In man, the outer ear has little of the

ear-trumpet action so beautifully shown by the donkey, and can be cut off with no noticeable effect upon hearing. Sound waves, entering the ear hole, strike the *tympanic membrane* within and set it into vibration. The membrane communicates its motion to the *ossicles,* an assembly of three little bones in the middle ear, and these concentrate the vibration upon a small opening from the middle to the inner ear. Thus the middle ear mechanism achieves the important result of setting into vibration the saline water that fills the inner ear.

The inner ear is first of all a cavity in one of the skull bones — a very small cavity, but complicated, with a round "vestibule" in the middle, and with a spiral passage and also

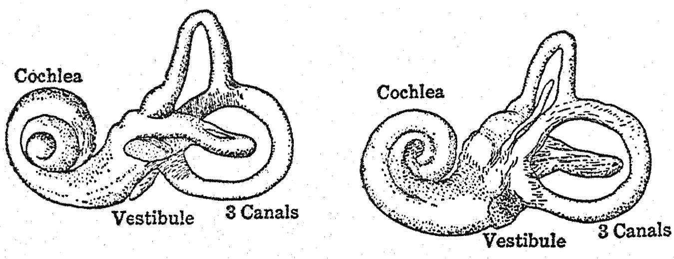


FIG. 27. — Two views of the internal ear. These views show the shape of the internal ear cavity. The sense organs lie inside this cavity. Notice how the three semi-circular canals lie in three perpendicular planes.

three "semicircular canals," opening out of the vestibule. The spiral passage, called the *cochlea* ("snail"), contains the auditory receptors. These are sense cells with delicate hairs on top, and with the fibers of the auditory nerve ramifying below. The sense cells stand in little rows, much like a regiment in column of fours, upon the *basilar membrane,* a narrow ribbon extending the length of the cochlea, and widening slowly and steadily from the base to the apex of the cochlea. The basilar membrane contains thousands of transverse fibers, stretched between two nearly parallel shelves of bone. The fibers appear to be more tightly stretched where they are

shorter, than at the wide end of the membrane. These details are important, because they suggest that the fibers of the basilar membrane are *tuned* to different rates of vibration; the long, slack fibers seem tuned to slow vibrations, and the short, taut fibers to rapid vibrations, with the intervening fibers tuned to intermediate vibration rates — just as in a piano or harp, only on an astonishingly small scale.

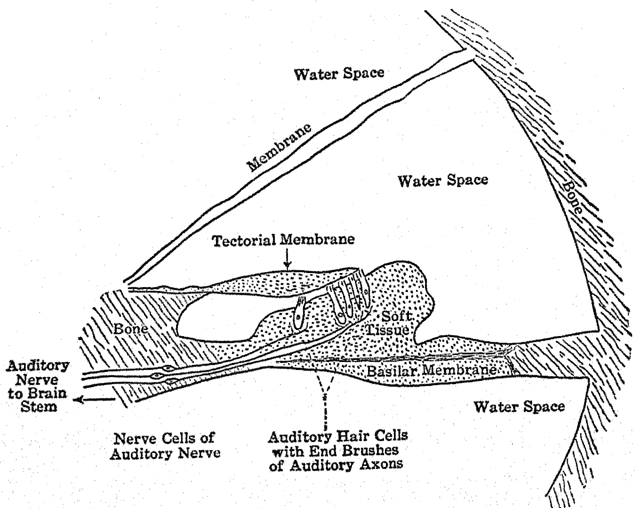


FIG. 28. — A single row of the sense cells of the cochlea; there are about 5,000 such rows, standing on the basilar membrane. Each of the three "water spaces" is to be thought of as a cross section of a long slender tube. The sound waves come in from the middle ear and vestibule by the uppermost of the three tubes, and go through the membranes into the lowest tube which conducts them back to a vent into the middle ear.

The famous "piano theory" of the action of the inner ear, the theory of Helmholtz, runs as follows: the water filling the inner ear, when set into vibration by the ossicles, transmits the vibrations to the basilar membrane, where they are taken up by the particular segment of that membrane that is tuned to the rate of the incoming vibrations. The hair cells standing on that segment of the basilar membrane are jiggled and thus

stimulated, and they in turn stimulate the auditory nerve fibers close underneath, and start a nerve current on its way to the brain. Different rate of incoming vibrations, different segment of the basilar membrane responding, different nerve current started towards the brain — thus is explained the fact that the ear distinguishes between sounds of different vibration rate, and gives us high, low and intermediate tones.

If a guinea pig is exposed, week in, week out, to a loud, steady tone of definite vibration rate, the result is that he becomes deaf to tones of that rate, and also, as shown by microscopic examination of his cochlea, that the hair cells on a portion of the basilar membrane degenerate. A slowly vibrating tone, in these experiments, injures the hair cells on the wider part of the basilar membrane, while a rapidly vibrating (high) tone injures the cells on the narrower part of the membrane. These experiments support the piano theory of hearing.[3]

Auditory sensations and their stimuli. An auditory sensation is the hearing of a sound, and is a response of the ear and brain to vibrations striking the ear. Heard sounds are roughly classified into tones and noises, tones being relatively smooth and steady, and noises mixed and irregular. Noise is produced by an irregular, unsteady medley of vibrations, tone by a sequence of uniform vibrations.

Heard sounds differ in loudness, in pitch, and in timbre. By *pitch* is meant the highness or lowness of a tone. The soprano voice has a high pitch, the bass a low pitch. By *timbre* is meant the characteristic sound of different instruments and other sources of sound. A violin, a cornet, and a human voice

[3] For a full account of this intricate subject of the theory of hearing, see G. Wilkinson and A. A. Gray. *The Mechanism of the Cochlea,* 1924. A brief statement of the case is given by Wilkinson in the *American Journal of Psychology,* 1927, vol. 38, p. 257. The experiments on deafening an animal for certain tones were done by Yoshii, 1909, and by M. Upton, *Proceedings of the National Academy of Sciences,* 1929, vol. 15, p. 284.

may all give the same note or pitch with the same loudness, but they can easily be told apart, and the difference between their tones is a difference in timbre.

Now we must find three ways in which the vibratory stimulus can differ, to account for these three differences in the sounds heard. Air vibrations, if simple, differ in only two independent ways, in amplitude or extent of the back-and-forth swing, and in the frequency or rate of the swing, the number of vibrations per second. Compound vibrations differ also in composition.

Loudness depends on the amplitude of the vibration; the greater the amplitude the louder the sound. But loudness depends also on frequency of vibration, since (1) for a given amplitude a more rapid vibration delivers more energy per second to the ear, and (2) the ear is more sensitive to medium and fairly high vibration rates than it is to low rates. Pitch depends definitely and exclusively on the vibration rate; the higher the rate, the higher the pitch of the heard sound. Timbre depends on the composition of a complex vibration.

The deepest audible tones have a vibration rate of about 20 per second, and the highest a rate of about 20,000. Outside of these limits, there are plenty of physical sounds, but they arouse no auditory sensation. A giant organ pipe may emit vibrations at the rate of only 16 per second, and shake the whole auditorium, but these vibrations cannot be heard. A tiny whistle gives out 30,000, 50,000 or more vibrations per second, and these can be heard by some animals but not by the human ear. Individuals differ in their upper and lower pitch limits, and the upper limit declines gradually after the age of twenty.

Though the ear is tuned to respond to this wide range of vibration rates, it is most sensitive to the middle part of this range, from 500 to 5,000 vibrations per second. Weaker vibrations can be heard at these middle rates than towards the extremes of the audible range.

Middle C of the piano, a note within the compass of all voices, though rather low for the soprano and rather high for the bass, has a vibration rate of about 260 per second. Go up an octave and you double the vibration rate; go down an octave and you halve the rate. The whole range of audible tones, from 20 to 20,000 vibrations per second amounts to ten octaves, of which music employs about eight octaves, finding little esthetic value in the highest and lowest audible tones. The smallest step on the piano, called the semitone, is one-twelfth of an octave; but this is by no means the smallest pitch difference that can be perceived. Most people can distinguish tones that are four vibrations apart, and keen ears can detect a difference of less than one vibration; whereas the semitone, at middle C, is a step of about sixteen vibrations. The semitone is simply the smallest step utilized by the European scale, which came down from the Egyptians and Greeks. Oriental music uses different scales, and smaller steps than the semitone.

Combinations of tones — timbre. If two or more notes sound together, a chord or discord is produced. The esthetic value of the combination depends partly on the relative vibration rates of the component notes, partly on the hearer's being accustomed or not to this particular combination (a wholly unfamiliar combination being distasteful and a perfectly familiar combination being trite and uninteresting), and partly on the total pattern of successive chords in which the given combination occurs. The chord or discord is a blend, from which you can, to some extent, especially after practice, hear out the component notes. The ear is to quite an extent an *analyzer*, making it possible to hear separate sounds out of a combination that simultaneously affects the ear. Thus, to take an obvious but important instance, you can hear what one person says to you through the din of other voices, street noises, etc. One sound does mask another to some extent, especially

when both are of about the same pitch, but the degree to which you can hear out the separate sounds is remarkable, if the fact is considered that all the air vibrations that enter the ear at the same time make up a complex wave motion. The ear has the power of breaking up the compound wave into its component waves. It is one merit of the piano theory that it explains how the ear can act as an analyzer. If the several parts of the basilar membrane are tuned to different vibration rates, then the parts corresponding to the vibration rates of a mixed sound entering the ear will respond separately, and so break up the complex wave into its elements.

Even a single voice, or a single note of an instrument, produces a combination of different vibration rates. Every sounding body gives off *overtones* along with its fundamental tone. The whole stimulus given off by middle C of the piano is a complex of fundamental and overtones, and the sensation aroused by this complex is a blend. We can, by careful attention and practice, hear out the overtones from the blend, but ordinarily we take the blend as a unit (just as we take the taste of lemonade as a unit), and simply get the characteristic quality of piano notes. Another instrument will give a different combination of overtones, and so a different blend, a different total quality. Thus the timbre of an instrument depends on the particular combination of overtones which it gives out.

Speech sounds. These are perhaps the most important of all sounds for human beings to hear. The great handicap of the deaf child, which shows in his IQ, is probably his inability to hear what other people say. If we had time for a thorough study here, we should begin with the production of speech sounds by the vocal cords and by the mouth. Suffice it to say that the vocal cords supply the voice element in speech sounds — an element that is absent in whispering and in the

"unvoiced" consonants, such as k, p, t, f and s. The vocal cords, like other sounding bodies, produce overtones along with the fundamental tone that is being spoken or sung. But the vocal cords, by themselves, give no vowels or consonants. These are produced by the different positions of the mouth, tongue and lips. In any position, the throat, mouth and nose

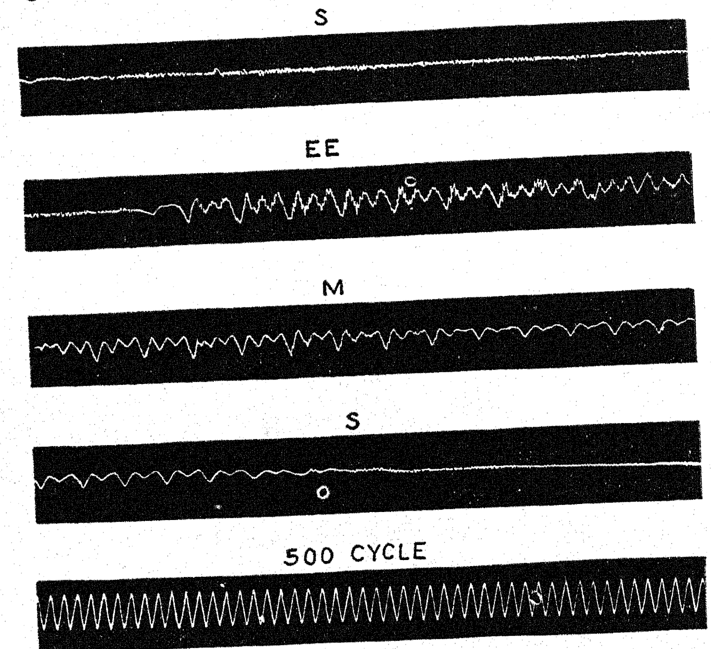


FIG. 29. — (From Harvey Fletcher, *Speech and Hearing*, published by Van Nostrand, 1929.) A record, obtained by the oscillograph, of the vibrations produced in speaking the word, "seems." The unvoiced *s* shows only rapid mouth vibrations. As *ee* begins, the vocal cord fundamental and overtones appear, with little superimposed mouth vibrations. The lowest line shows a simple tuning fork vibration at the rate of 500 per second.

form a chamber that strengthens or dampens certain of the vocal cord overtones, and that also adds new, high tones to the vibration complex issuing from the mouth. These mouth

and nose tones can be heard in whispering, when the vocal cords are silent.

Compare the mouth positions for sounding *o* as in " tone " and *ee* as in " teem." The tongue and lips take different positions in the two cases. The *o* position strengthens the vocal cord overtones and adds a mass of high but faint mouth tones. The *ee* position rather damps the vocal cord overtones, but adds a mass of strong, high mouth tones. Notice also the position for saying *s*: the tongue is brought up to the base

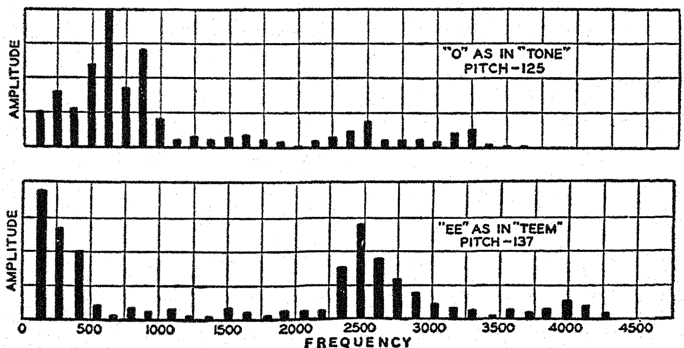


FIG. 30. — (From Harvey Fletcher, 1929.) An analysis, made by an electric analyzer, of the component vibrations in the vowels *o* and *ee*. The location of the bars along the base line indicates the vibration rate of each component, while the height of each bar indicates the relative strength of each component.

of the upper teeth, leaving a narrow passage for the air, which whistles through, giving a mouth tone of very high vibration rate (about 7,500 per second), which can readily be heard in whispering the sound *s*. If you sound *z*, the corresponding voiced consonant, you can hear both the vocal cord tone and the hissing at the front of the mouth. You can feel them both, as well, in pronouncing this letter. Each speech sound is a different combination of tones. The development of telephone, phonograph and radio engineering has made it possible to obtain beautiful records and analyses of speech sounds.

In hearing speech, we do not hear out the component tones to any great extent, but recognize the total complex as a familiar blend. Even a whole syllable, composed of several speech sounds, is heard as a total pattern.

From the high pitch of many of the mouth tones that enable us to distinguish one vowel or consonant from another, we see how useful it is to have ears very sensitive to what might otherwise seem absurdly high vibration rates, from 2,000 to 5,000 per second, away above the range of the human voice, i.e., of its fundamental tones. These high mouth tones are often very weak in comparison with the vocal cord tones, with the result that the hearer can hear plenty of voice, but no speech. For the same reason, as the sensitiveness of the ear to high tones decreases with age, one finds it more difficult to hear what people are saying, though one can still hear the rumble of their voices.

Binaural hearing, or hearing with two ears, is a fact deserving some consideration. The nerve connections from both ears come together within the brain, and for the most part the two ears function as a single organ exposed, more than a single ear could be, to stimuli from all quarters. A person may, however, be deaf in one ear without serious loss of hearing, except for imperfect *localization* of sounds. All that the ears directly tell us of the place from which a sound comes is the single fact that it comes from the right or from the left. A sound from the right side strikes the right ear with more force than the left, and strikes it a little sooner, and thus binaural hearing gives a definite right-left distinction. Even binaural hearing furnishes no further direct data for localizing the sound; it tells us nothing as to whether a sound comes from in front or behind, from above or below. But, of course, we can move the head, as the donkey moves his ears, and so discover the direction of the sound. Moreover, in familiar surroundings and with familiar sounds, we have learned to use all sorts

of indirect indications of the direction and even the distance of the sounding body; and the person with one deaf ear is at no great disadvantage in this elaborate, learned localization of sounds.

The elementary auditory sensations. Simple tones, free from overtones and from all noise additions, are the elements, and such tones can be arranged in a continuous pitch series, from the lowest to the highest, with no breaks, sudden transitions, or "salient sensations" such as we found in the sense of smell. The notion of a few elements, which was helpful in understanding skin sensation, taste, and perhaps smell, has no value in the case of hearing. Every tone, provided it is free from overtones, etc., is as elementary as any other. This continuous scale of auditory responses, together with the analyzing power of the ear, makes the ear a much better registering instrument for sound than the eye is for light. Incidentally, that is why we can play with tones in so much more elaborate ways than we can play with colors — why music is so much more elaborate than any pure color art. In compensation, to be sure, the eye is far superior to the ear as a form and space sense.

THE SENSE OF HEAD POSITION AND MOVEMENT

It is a surprising fact that some parts of the inner ear are not connected with hearing at all. In fact, if we trace the ear back in the animal series, we find that its first use was to respond not to vibrations, but to movements and positions of the head. The cochlea is a recent addition to the ear, and so also are the middle and outer ear. The vestibule and the semicircular canals are the old parts, and they are more fundamentally important than hearing, because, being stimulated by positions and movements of the head, they provide the sensory data for the maintenance of posture, orientation with respect to gravity, equilibrium, and steadiness of movement.

They enable the fish to keep right side up in the water, the bird in the air, the frog to right himself instantly if placed on his back, and the cat to land on her feet when falling from a tree.

There are receptors in the vestibule and semicircular canals, consisting of hair cells, somewhat similar to those in the cochlea. In the vestibule, the hair-tips of the sense cells are matted together, and in the mat are imbedded little particles of stone, the *otoliths*. When the head is inclined in any direction, these heavy particles sag and bend the hairs, so stimulating them; and the same result occurs, by inertia of the heavy particles, in any sudden starting or stopping of motion of the body. Around the base of the hair cells twine the fine terminations of sensory nerve fibers, which are excited by the activity of the sense cells, and pass the activity on to the brain.

Each semicircular canal has a bunch of hair cells, the long hairs sticking up into the water like reeds growing in a stream. Now, though the canals are called "semicircular," each is considerably more than a semicircle and, opening at each end into the vestibule, amounts to a complete circle. Rotating the head produces, by inertia of the water, a back flow in one or more of the canals, which bends the hairs and stimulates them. As the semicircular canals lie in three planes at right angles to each other, they provide a complete analyzer for head rotations in any direction. Meanwhile, the otolith receptors, which are also arranged in different planes, analyze the positions and rectilinear movements of the head. Thus the inner ear as a whole — quite apart from the cochlea — provides a complete analyzer for head positions and movements.

This sense is strongly stimulated by whirling, swinging, sudden starting or stopping (as in an elevator), turning somersaults, etc. The resulting sensations have a dizzy quality, and become strong after continued rotation. It is not certain that all dizzy sensation arises from the inner ear. But it is certain,

from physiological experiments involving destruction of part or all of the inner ear or its nerves, that postures, righting movements, and steadiness of progression depend on this organ, as well as on the muscle sense.

Another thing that is certain is that our ability to observe slight rotations depends on the inner ear, for it is lost when both inner ears are spoiled by disease. If a person is placed,

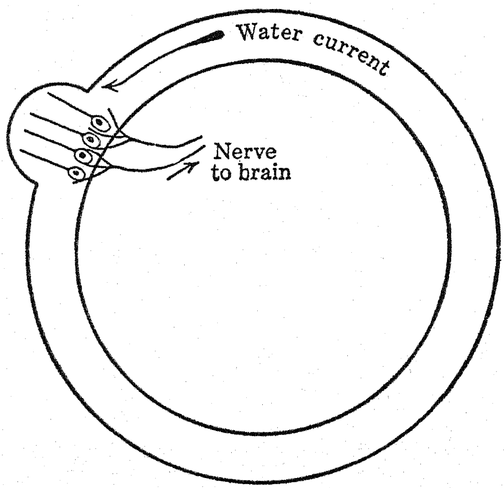


FIG. 31. — How the sense cells in a semicircular canal are stimulated by a water current. This current is itself an inertia back-flow, resulting from a turning of the head in the opposite direction.

blindfolded, in a chair that can be rotated without sound or jar, he can easily tell when you start to turn him, and in which direction. If you keep on turning him at a constant speed, he soon ceases to sense the movement, and if you then stop him, he believes you are starting to turn him in the opposite direction. He senses the beginning of the rotation because this causes a back flow in the canals; he soon ceases to sense the uniform rotation because friction in the slender canal soon stops the back flow; and he senses the stopping of the rotation

as if it were a starting in the opposite direction because the water in the canal keeps on moving by inertia when the head rotation ceases.

THE SENSE OF SIGHT

The eye, like the cochlea of the ear, owes its importance in behavior to the fact that it is a distance receptor, and so en-

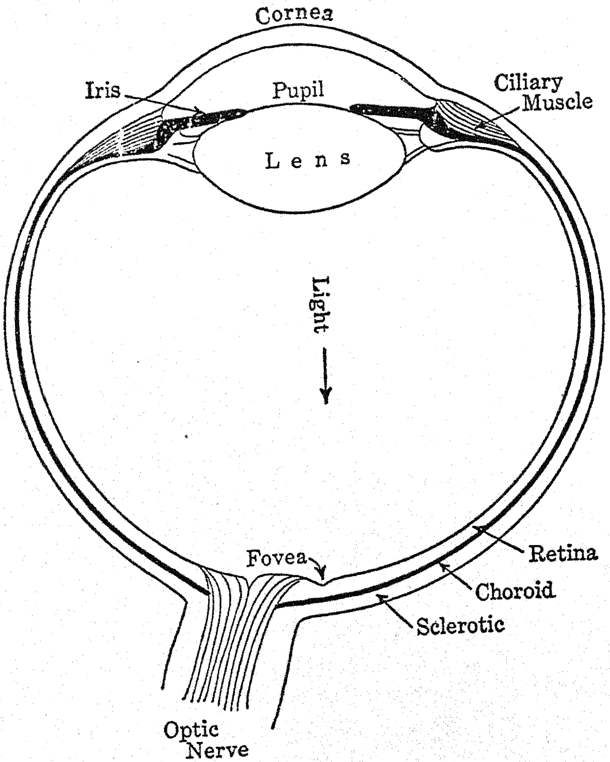


FIG. 32. — Horizontal cross section through the right eyeball.

ables the organism to make preparatory reactions, and to adjust itself to a wide environment. Even the protozoa, without any sign of specialized receptors, respond to light by either moving towards it or moving away from it. Higher in the

animal scale, we find simple receptors in the form of pigment spots supplied by sensory nerves. These simple receptors enable the organism to respond to light or dark, but not to color, form, or the distance of the object from which the light comes. The further development of the eye gives receptors that respond differently to different colors, and accessory apparatus that focusses a clear picture on the spreadout receptors, and so makes it possible to see the forms of objects.

Accessory apparatus of the eye. The human eye is a registering optical instrument, like the camera. In fact, it is a camera, the sensitive plate being the retina, which differs indeed from the photographic plate in recovering after each exposure so as to be ready for another. Comparing the eye with the familiar camera, we find that the outer tough white coat of the eyeball, the sclerotic coat, takes the place of the wood or metal of which the camera box is made, while the black choroid coat, lining the sclerotic, corresponds to the coating of paint used to blacken the inside of the camera box and prevent stray light from entering and blurring the picture. At the front of the eye, where light is admitted, the choroid gives place to the iris, with the hole in the center that we call the pupil of the eye. The iris has little muscle fibers in it, which regulate the size of the pupil; it corresponds to the adjustable diaphragm of the camera. The sclerotic gives place at the front of the eye to the curved, transparent cornea, which is a strong lens. Just behind the pupil is another lens, adjustable in curvature by the action of the little ciliary muscle. This muscle corresponds to the focussing mechanism of the camera; by it the eye is focussed on near or far objects. The aqueous humor (in front of this lens) and the vitreous humor (behind the lens) fill the eyeball and keep it taut and spherical, while still, being transparent, they allow light to pass through them to the retina. The retina is a thin membrane, lining the rear of the eyeball, and having the form of a hollow

hemisphere. The retina is the sensitive plate; it contains the visual receptors. Among the accessory apparatus should be counted the lids, the tear glands, and the six muscles that turn the eyeball in every direction.

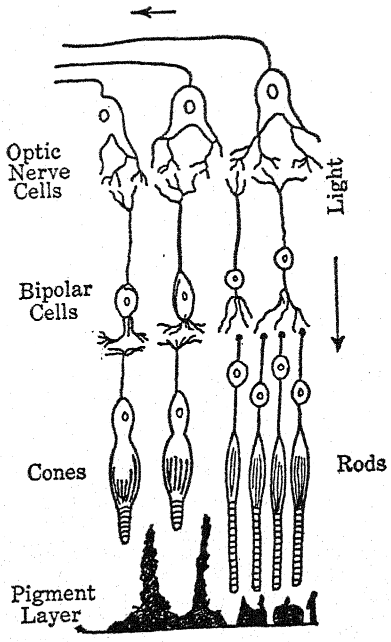


FIG. 33.—Sense cells and nerve cells of the retina. Light, reaching the retina from the interior of the eyeball (as shown in FIG. 32), passes through the nearly transparent retina till stopped by the pigment layer, and then and there arouses to activity the tips of the rods and cones. The rods and cones pass the impulse along to the bipolar cells and these in turn to the optic nerve cells, the fibers of which extend by way of the optic nerve to the thalamus in the brain.

The visual receptors. The retina contains sense cells of two forms, the rods and the cones. They are located at the back of the retina, next to the pigment layer. Probably the incoming light first produces some chemical and electrical change in the pigment, and this change stimulates the rods and cones.

The tips of the rods and cones, next to the pigment layer, correspond to the hairs of other sense cells that we have met with, and no doubt are the sensitive part of the rods and cones. Both the rods and the cones connect at their base with nerve cells that pass the activity along through the optic nerve to the brain.

The cones are more highly developed structures than the rods. At the fovea, a little depression in the retina, straight back from the pupil, only cones are present, and this is the "center of clear vision," where the fine details of objects are best seen. Outside of this little central region, rods and cones are intermingled, with fewer and fewer cones the further out in the retina you go. The further out you go, also, the poorer both form sense and color sense, from which fact it is believed that response to both form and color depends mostly on the cones.

Rod and cone vision; adaptation of the retina to dim and strong light. The first, prompt reaction of the eye to change of illumination is a widening or narrowing of the pupil. But there is a slower and more effective change that occurs in the retina itself, and that amounts to a sensitizing of the retina to the degree of illumination. Go into a dark room, and at first all seems black, but by degrees, provided there is a little light filtering into the room, you begin to see, for your retina is becoming dark-adapted. Come out of the dark into a bright place, and at first you are "blinded," but you quickly get used to the bright light and see distinctly, your retina having become light-adapted.

While in the dark, after becoming dark-adapted, you will notice that you see only light and shade and no colors. Another significant fact is that the fovea, which has only cones and no rods, has the best color vision, but does not become well dark-adapted and is almost blind in very dim light. These facts are taken to mean that vision in dim light, or

twilight vision as it is sometimes called, is rod vision and not cone vision. The rods, then, become sensitized to very faint light, far outstripping the cones in this respect. On the other hand, not the rods, but only the cones, have color vision.

Stimulus and sensation in the sense of sight. Before tackling color vision and the question of elementary color sensations, we need to review a few elementary facts regarding light. Without going into the physics of light to any extent, we can say that light has so much of the vibratory character as to allow us to speak of its vibration rate, the same as in sound. Only, while the vibration rate of audible sounds varies from 20 to 20,000 per second, that of visible light is in the region of 500,000,000,000,000 per second. While sound travels through the air at a speed of 1,100 feet per second, light travels through space at a speed of 186,000 miles per second. Instead of speaking of the vibration rate of light, it is more customary to speak of its wave-length (wave-length and vibration rate being inversely proportional to each other). In the rainbow, or spectrum, light of the different wave lengths is separated and spread out in order before us. At the red end of the spectrum, the wave length of the light is 760 millionths of a millimeter, and at the violet end it is 390 millionths. In between are waves of every intermediate length, appearing to the eye as orange, yellow, green and blue, with all their transitional hues. A wave length of 600 gives yellow, one of 500 gives green, one of 470 gives blue, etc. Outside the limits of the visible spectrum, there are waves still longer and shorter, incapable of arousing any sensations of light, though the long waves, beyond the red, excite the warmth spots of the skin, and the very short waves, beyond the violet, while arousing none of the senses, do tan the skin and produce other physiological effects.

Now let us forget physics for a moment, and ask about *sensations* of light and color. Let us assemble a collection of

bits of color of every shade and tint, and try to arrange them in some kind of order. We should find that we could sort out a pile of reds, a pile of blues, a pile of browns, a pile of grays, etc., but the piles would tend to shade off into one another. The striking fact would be the gradual transitions. We can arrange them in *series* better than we can classify them. They can be arranged serially in three ways, according to brightness, according to color-tone, and according to saturation.

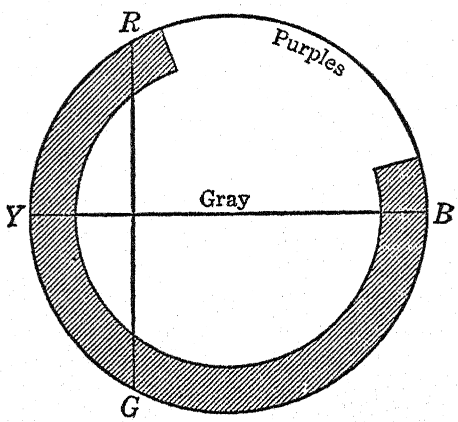


FIG. 34.—The color circle. *R, Y, G* and *B,* stand for the colors red, yellow, green and blue. The shaded portion corresponds to the spectrum or rainbow. Complementary colors (see later) lie diametrically opposite to each other on the circumference.

A *brightness* series runs from light to dark. If we stuck to the dead grays, we could arrange them all in a single series from brightest white to deepest black. If we sandwiched in other bits of color in our gray series, we should not always be certain exactly where to place a given red or blue, but in a general way we could locate every bit of color in the brightness series.

The *color-tone* series is best arranged from a collection of full or saturated colors, without the dull shades or pale tints. If we take red and yellow, we can fill in between with the oranges, some of them more reddish and some more yellowish.

Continuing beyond the yellow, we should proceed to yellowish green, to straight green, to bluish green and greenish blue, and so on to straight blue. Then we should run into violet, which is blue tinged with red, and proceeding we should add the purples, more and more reddish, till we found ourselves back at red again. It makes no difference where we start; the color-tone series is a circular series, and quite different in this respect from the brightness series, or from the pitch series in sound.

A *saturation* series runs from full-toned colors to those that are grayish or whitish, with little of the specific color-tone left in them. It is best arranged by taking a strong red or blue or any color as one end of the series, and a dead gray of about the same brightness as the other end, and then filling in, from your unlimited collection of bits of color, sticking always to the same color-tone and always to the same brightness. Thus you get a series of reds, or of blues, all having the same color tone and all the same light-value, but with different amounts of gray mixed with the color.

Here, then, we have three ways in which visual sensations differ among themselves. They differ in brightness, in color-tone, and in saturation. If we now return to our physics, and ask what difference in the stimulus gives each of these differences in sensation, we find that, in a broad way, brightness corresponds to the energy of the light striking the retina, color-tone to its wave-length, and saturation to the degree of purity of the light, i.e., to the absence of mixture in the wave-lengths that strike the same part of the retina.

These are the general correspondences between the physical light and the visual sensation, but the whole relationship is much more complex. Brightness depends, not only on the energy of the stimulus, but also on its wave-length. The retina is most sensitive to waves of medium length, corresponding to the yellow of the spectrum. A given amount of physical energy arouses a much stronger light sensation if its wave-

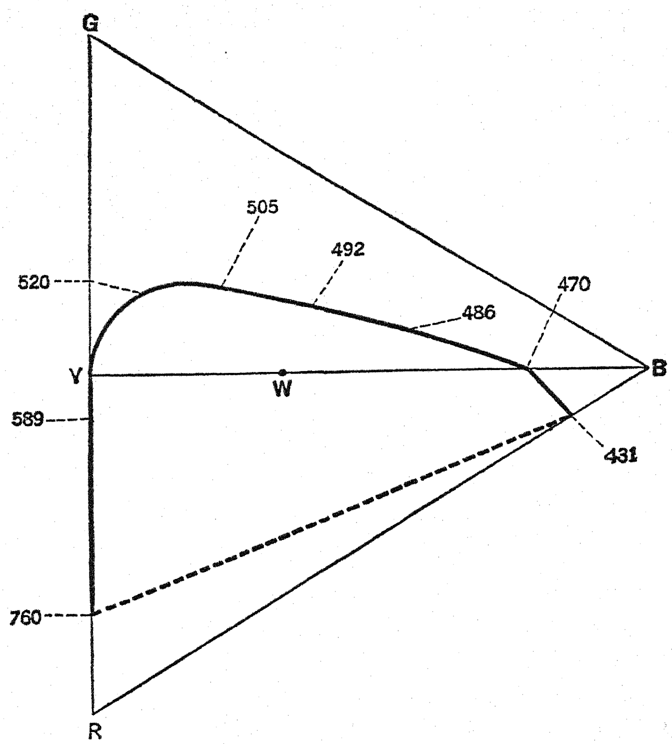


FIG. 35. — (After König.) The color triangle, a map of the laws of color mixture. The spectral colors are arranged in order along the heavy solid line, and the purples along the heavy dotted line. The numbers give the wave-lengths of different parts of the spectrum. Inside the heavy line are located the pale tints of each color, merging from every side into white, which is located at the point *W*.

Suppose equal amounts of two spectral colors are mixed: to find from the diagram the color of the mixture. Locate the two colors on the heavy line, draw a straight line between these two points, and the middle of this line gives the color-tone and saturation of the mixture. For example, mix red and yellow: then the resulting color is a saturated reddish yellow. Mix red (760) and green (505): the resulting yellow is non-saturated, since the straight line between these two points lies inside the figure. If the straight line joining two points passes through *W*, the colors located at the two points are complementary.

Spectral colors are themselves not completely saturated. The way to get color sensations of maximum saturation is first to stare at one color, so as to fatigue or adapt the eye for that color, and then to turn the eye upon the complementary color, which, under these conditions, appears fuller and richer than anything otherwise obtainable. The corners, *R, G,* and *B,* denote colors of maximum saturation, and the whole of the triangle outside of the heavy line is reserved for super-saturated color sensations.

length is medium, than if it belongs near the red or the blue end of the spectrum.

Color mixing. Color-tone, as has been said, depends on the wave-length of the light stimulus, each color-tone being a response to one particular wave-length. But this is not the whole truth. Any color-tone can be got without its particular wave-length being present at all, by mixing wave-lengths lying on both sides of this particular one. For example, the orange color given by wave-length 650 is given also by mixing wave-lengths 700 and 600; a mixture of red and yellow lights gives orange.

A point of experimental technique: in mixing colored lights for the purpose of studying the resulting sensations, we do not depend on mixing paints, but we throw both lights together into the eye or on a white screen. We can also, by virtue of a certain lag or hang-over in the responses of the retina, mix lights by use of the "color wheel," which throws them in rapid alternation into the eye.

By mixing red and yellow, in different proportions, we get all the color-tones intervening between red and yellow — all the oranges. By mixing yellow and green we get all the yellowish greens, and by mixing green and blue, all the greenish blues. Finally, by mixing blue and red, we get violet and the purples. Purple has no place in the spectrum, since it is a sensation which cannot be aroused by the action of any single wave-length, but only by the mixture of long and short waves.

Now what happens if we mix yellow and blue? Those who know about mixing paints will say that you will get green; but mixture of paints is decidedly not mixing lights, for each paint *absorbs* or subtracts part of the light, and the effect of the double subtraction is very different from *adding* blue and yellow. If you add blue and yellow, you get white or gray. Two wave-lengths which, when acting together on the retina,

give a white or gray sensation, are called *complementary*. Yellow and blue, then, are complementary.

Red and green are sometimes said to be complementary, but such a statement is inaccurate, for if you take typical red and green, such as brick-red and grass-green, and mix them, you get a dull yellow, but never a white or dead gray. The complementary of red is bluish green, and that of green is purple.

Red and green, however, like blue and yellow, may be called a *disappearing color pair*. When you mix blue and yellow, both disappear, and you get the sensation of white, in which there is no resemblance to either yellow or blue. So, when you mix red and green, both disappear, and the sensation of yellow emerges.

Otherwise stated, the facts of color mixture are these: you can get *blends* of red and yellow, of yellow and green, of green and blue, and of blue and red, but there are no sensation blends of red and green, nor of yellow and blue.

Yet another statement of the facts is that all color-tones, including white and gray, can be obtained by employing various mixtures of four wave-lengths, red, yellow, green and blue. Moreover, you do not need the yellow, since you can get it by mixing red and green. All the colors, including white, can be got by mixing red, green and blue. This striking fact is the basis of the well-known Young-Helmholtz theory of color vision, which teaches that there are just three elementary responses of the retina to light — three elementary color sensations, red, green and blue, all other colors, including white, being combinations of these three elements.

This theory is unsatisfactory to the psychologist, first because it treats white as a blend of red, green and blue, which is absurd on the face of it. No one can pretend to find any trace of those colors in the sensation of white. White is as simple and elementary as any of them. Yellow, also, refuses

to be called a reddish green; it too bears the marks of an element. A further objection to this theory lies in the facts of color-blindness, next to be considered.

Color-blindness. There are two kinds of color-blindness, total and partial. *Total color-blindness* amounts to rod vision, which gives light and dark, but none of the spectral colors. The outermost zone or ring of the retina, where cones are very scarce, is almost totally color-blind. Some individuals, very few, are totally color-blind over the whole retina, having apparently no cones but only rods; their vision is poor, as would be expected.

With regard to color theory, we learn from total color-blindness that colorless sensations are not necessarily combinations of red, green and blue, since they occur when those color responses are not in the individual's power. Rod vision is certainly more primitive than cone vision, and we thus get the suggestion that white-black-gray vision is more fundamental than red-yellow-green-blue vision.

Partial color-blindness is *red-green blindness.* It is very uncommon among women, but present in three or four per cent of men. It is not a disease, and is not associated with any other defect of eye or brain. Nor can it be cured or corrected by training. It is simply a native peculiarity of the color sense, a reduced or simplified form of it. The red-green blind individual has the sensations of yellow and blue, along with white, black and the grays — but no red or green. What appears to the fully equipped eye as red or green appears to him as dull yellow, and what appears to the normal eye as greenish blue, violet and purple appears to him as dull blue. He has difficulty in picking strawberries, in obeying the traffic lights, and in selecting his neckties.

Now every one is red-green blind in the intermediate zone of the retina, between the central region which has full color sense and the outermost zone which is almost totally color-

blind. This statement can be checked by taking bits of various colors and moving them slowly from the very margin of the field of view towards the center, all the while keeping the eyes directed straight ahead. When the bits first become visible, at the margin of the field of view, they have no color other than gray, then they take on a blue or yellow tinge, and finally, near the center of vision, they acquire their red or green components and show in their " true " colors.

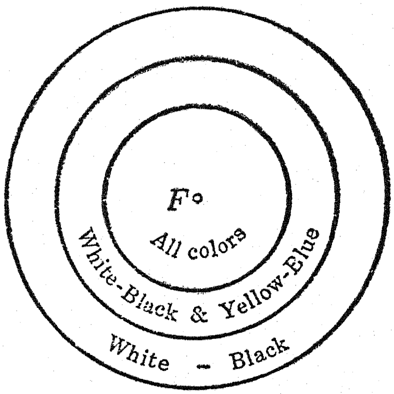


FIG. 36. — Color zones of the retina. *F* is the fovea, or central area of clearest vision.

As to theory, again, we learn from red-green blindness that yellow, as a visual response, is certainly not a compound of the red and green responses. The yellow response is made by individuals who cannot make the red or the green response. Yellow is confirmed in its claim to be an element of visual sensation.

Theory of color vision. Better than the Young-Helmholtz theory or than any other that has been sufficiently discussed, the Ladd-Franklin theory seems to sum up the facts.[4] This theory treats of the color sense as having passed through three stages

[4] This theory is fully presented by its author in the following book: Christine Ladd-Franklin, *Colour and Colour Theories,* 1929.

of development. In the earliest stage the only elements were white and black; the second stage added yellow and blue; and the third stage, red and green. The outermost zone of the retina is still in the first stage, and the intermediate zone in the second, only the central retinal area having reached the final stage. In red-green blind individuals, the central area remains in the second stage, and in the totally color-blind the whole retina is still in the first stage. There is evidence that some animals normally remain in the first stage, and some in the second.

In the first stage, one response, white — in its various degrees of intensity, down to dark gray — was made to light of whatever wave-length. In the second stage, this single response divided into two, one aroused by the long waves and the other by the short. The response to the long waves was the sensation of yellow, and that to the short waves the sensation of blue. In the third stage, the yellow response divided into one for the very longest waves, corresponding to red, and one for medium waves, corresponding to green. When, with an eye in the third stage, we mix red and green lights, we cannot get a blend of the red and green sensations because the eye reverts to the more primitive yellow response — the red and green disappear, and the old yellow takes their place. Similarly, when we try to arouse the yellow and blue responses together, they disappear and give place to the primitive white response out of which they developed.

The theory goes on to explain what chemical processes may occur in the retina to produce these results. A word should be added about *black*. Black is sometimes said to be simply the absence of light. But black is as positive a sensation as any. We even speak of an "intense black." Black is a response made, not to the mere absence of light, but to the sudden withdrawal of light, or to the absence of light in an area surrounded by light.

After-images. A better name would be *after-sensations.* The main fact is that the response outlasts the stimulus. This is true of a muscle, and it is true of a sense organ. The ear is very quick in recovery, and gives almost no after-sensations, but touch after-sensations can easily be felt after a momentary touch on the skin. Visual after-sensations are the most interesting. If you look towards a lamp, but with a book in

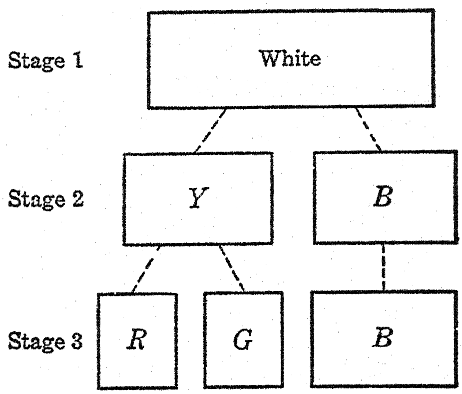


FIG. 37. The Ladd-Franklin theory of the evolution of the color sense.

front of your eyes to serve as a screen, remove the screen for an instant and then replace it, you will continue for a short time to see the light after the stimulus has been cut off. This *positive after-image* is like the main sensation, only weaker. There is also a *negative after-image,* best obtained by looking steadily at a black-and-white or colored figure for fifteen seconds, and then looking at a gray background. After a moment's delay, a sensation develops in which black takes the place of white and white of black, while for each color in the original the complementary color now appears. This phenomenon of the negative after-image is essentially the same as color adaptation: if you remain for some time in a room illuminated by a colored light, by degrees the color sensation

bleaches out so that everything looks the same as if the light were white; and if now you go into a place with white illumination, everything is tinged with the color complementary to that to which you have become adapted by being long exposed to it.

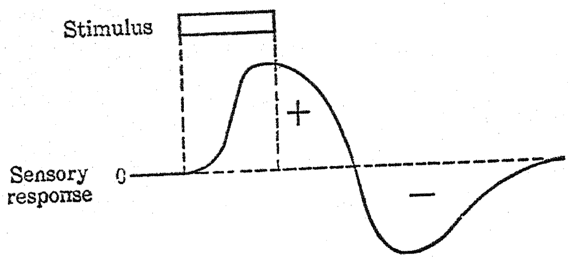


FIG. 38. — The visual response outlasts the stimulus. The progress of time is supposed to be from left to right in the diagram. After the stimulus ceases, the sensation persists for a time, at first as a positive after-image, and then as a negative after-image, a sort of back swing.

Visual contrast. Contrast is still another effect that occurs in other senses, but most strikingly in vision. After looking at a bright surface, one of medium brightness appears dark, while this same medium brightness would seem bright after looking at a dark surface. This is evidently the same thing as the negative after-image or as adaptation, and is exactly parallel to the adaptation noticed before in the temperature sense. After looking steadily at one color, and then turning the eyes upon the complementary color, the latter appears more saturated than usual; in fact, this is the way to secure the maximum saturation in color sensation. These are examples of "successive contrast."

"Simultaneous contrast" is something new, and peculiar to the sense of sight. If you take two pieces of the same gray paper, and place one on a black background and the other on white, the one on black looks much brighter than the other. Spots of gray on a colored background are tinged with the com-

plementary color. Any two adjacent colors produce contrast effects in each other, though we do not usually notice them any more than we usually notice the after-images that occur many times in the course of the day; for we habitually disregard sensations that do not represent objective facts.

The eye as a space and form sense. All this attention that we have given to the color sense should be balanced by at least a word in recognition of the fact that it is spatial forms and relations which the eye is best suited to give. As an analyzer of vibrations, the eye is quite inferior to the ear, since the ear enables its possessor to identify the vibration rate of a sound, and to pick out separate vibrations in a mixture. The eye, with its few elementary color responses, can tell very little of the composition of the light; various different combinations of light waves arouse the same sensation. But the visual receptors are spread out in a receiving screen, with a lens in front to give good definition of objects, and thus the eye reveals the form and location of objects far better than the ear, and far more quickly than the touch and muscle senses, which also, in combination with each other, make a good space sense. To account for the visual sense of space and form, we need not assume any further elementary responses of the rods and cones than we have found necessary to account for the color sense. Form is given by the arrangement on the retina of colored patches, just as in an oil painting.

To do justice to the eye, however, we must not neglect two further facts: that the eye moves, and that there are two eyes.

Eye movements. The iris expands and contracts the pupil; this is the pupillary reflex to change of illumination. The ciliary muscle alters the shape of the lens, and so focusses on either near or far objects. The eyeball is moved in its socket by its six muscles, and the two eyes are so harnessed together in their motor nerve centers in the brain that they always move as a team. They execute two kinds of coördinated move-

ment. In looking here and there about the landscape, the two eyes turn together like a pair of horses, and this is the *conjugate* movement of the eyes. But in turning from a far to a near object, the eyes are brought from their parallel position into one of *convergence,* such that the foveas of both eyes receive the light from the particular object looked at.

The conjugate movement, on being recorded photographically, by Dodge and others, is found to have two varieties, called the jump movement and the pursuit movement. The jump movement carries the eyes from one object to another, while the pursuit movement follows the same object as it moves. Watch the eyes of some one who is looking at a scene of any sort, and you will see them jumping hither and thither, as his attention shifts from one part of the scene to another. The eyes fixate one point for a short time, jump to another point and remain there for a moment, and so on about the field of view. In reading, as the result of practice, the eyes follow a more regular procedure, fixating a series of points in the single line of print, with quick jumps from each fixation point to the next, then making a longer reverse jump to the beginning of the next line, and so on. To appreciate the value of this jumpy movement, we need to understand that each jump occupies but a thirtieth to a fiftieth of a second, while the fixation pauses between jumps last much longer, with the result that over ninety percent of the time spent on a line of print is fixation time, less than ten percent being consumed in making the jumps. It has been found that nothing of any consequence is seen during the jumps, and that the real seeing takes place only during the fixations. The jump movement is simply a means of passing from one fixation to another with the least waste of time.

The eye sees an object distinctly only when at rest with respect to the object. If the object is still, the eye must be still to see it distinctly. Ask a person to abstain from the

jumpy movement, and let his eyes "sweep over" the scene, and he will confidently attempt to do so, but if you watch his eyes you will find them still jumping. "Sweeping the glance" is a myth. It can only be done if there is a moving object to follow. If you could execute the smooth sweeping movement over a scene, it would yield you no clear view of anything, but only a blur, like that obtained when the camera moves during an exposure. But if an object is moving with moderate speed, the eyes can keep pace by a pursuit movement, so remaining at rest upon the moving object, and getting a clear picture of it.

Binocular vision. In most animals, the eyes look to the side, and have different fields of view, and their combined fields compass almost the entire horizon. Though we can see the utility of this sort of binocular vision, it is difficult for us to imagine what it would be like, since the human eyes are located close together, looking forward, receiving almost the same stimulation, and functioning as a single organ. We know by experience what this type of binocular vision is like, but it takes some thought and experimentation to discover its utility. How does this type of binocular vision differ from monocular vision, and what advantage does it have?

First, the incoming currents from the two eyes reinforce each other in the brain, so that binocular vision is more impressive than monocular; it enables us to see slightly better and to respond somewhat more quickly. Still, the one-eyed individual is under no great handicap in these respects.

Second, two eyes are an advantage in near vision, just because they then get *slightly different views* of the same object. The right eye sees a little more around to the right of a solid object held in the hands, and the left eye a little more around to the left. Thus the solid object is more completely seen at any one moment with two eyes.

Third, the brain responds to these slightly different simul-

taneous views of the same object, delivered by the two eyes, by not only seeing more of the solid object, but by seeing the solidity of it, the third dimension of it. A single eye gives a flat picture, such as can be given by a photograph or a painting. But the discrepancy between the two flat pictures, delivered by the two eyes in viewing a solid object near at hand, is utilized by the brain to see the object in three dimensions.

Among man's special characteristics, which make his behavior different from that of animals, are the erect posture, freeing the hands from use in locomotion for use in manipulation of objects, the development of the hand as a manipulatory organ, and the forward position of the eyes, which affords a three-dimensional view of objects as they are manipulated. Thus the human type of binocular vision fits in beautifully with man's manual dexterity and with his attentiveness to objects which can be handled. Binocular vision reveals the third dimension also in objects that are somewhat further off, up to a hundred feet or more. But the eyes are so close together that they get essentially the same view of any distant object, so that the solidity effect of binocular vision disappears in the distance.

The *stereoscope* is a convenient instrument for experimenting upon binocular vision. It presents separate views to the two eyes. If the views presented are views of the same object or scene, photographed from two positions close together, the third dimension comes out very realistically when they are combined by aid of the stereoscope. If radically different figures or colors are presented to the two eyes, by aid of the stereoscope, the usual result is *retinal rivalry*. First what is before one eye is seen for a time, then what is before the other, and so on alternately — as if the brain were unable to make any synthesis of the two discrepant images, and had to accept the one or the other at any moment. However,

sometimes other results occur. A red before one eye and a yellow before the other may be seen as the orange blend (binocular color mixture), or the one color may even be seen through the other, as if through a colored curtain. The general principle seems to be that the brain uses the data from the two eyes the best way it can, with a bias towards objectivity.

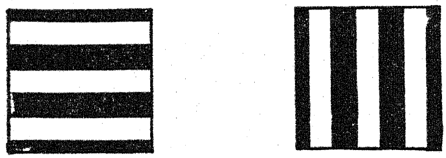


FIG. 39. — Binocular rivalry. Even without the aid of a stereoscope, different fields may be presented to the two eyes. Hold the figure close to the eyes, so that one half of it shall be before the right eye, and the other half before the left; and let the eyes relax and simply stare steadily, with no effort to see distinctly. If this is done right, the two squares will slide over each other so as to be superposed and seem to lie in the same place. Hold this position, staring steadily and passively, and observe whether there is any shifting between the contents of the two squares, first one appearing and then the other, alternately.

USES OF SENSATION

The readiest answer to the question, what use the organism makes of sensations, would be that it uses them to get acquainted with the world and the objects and happenings therein. Knowledge comes through use of sensory data. But anyone interested in music, or in painting and decoration, or in the perfumer's art or the culinary art, might very well bring up the fact that sensations are utilized for esthetic purposes as well as for knowledge. He might also refer back to our chapter on feeling and emotion, in which the statement was made that the life of feeling, certainly very significant to the individual himself, was based on sensations — on sensations taken not as data to be analyzed, but as a blended background. Then the student of behavior would speak up, and

point out that the prime use of sensory stimuli was to initiate and guide motor response. Feeling, to his mind, is rather a luxury than a necessity, and knowledge has no real use except as leading to action.

While all of the senses are important in arousing motor (and glandular) responses, special importance attaches to the eye, the ear and the muscle sense. The muscle sense, along with the vestibule and semicircular canals of the ear, are fundamentally important in maintaining posture and steadiness and efficiency of muscular action. The eye also is a steadier of posture and movement, as can be seen from the greater sway and unsteadiness that occurs when the eyes are closed. The eye is specially important in the guidance of accurate hand movements. The cochlea of the ear is similarly important in the precision of one very important class of movements, namely, the speech movements, as can be judged from the lack of precision of those movements in deaf persons who have learned, with great difficulty, to talk after a fashion.

The esthetic and motor uses of sensation undoubtedly deserve much fuller treatment than we are able to allow them here. What we propose to do in the next few chapters, however, is to follow up sensation into the field of knowledge. After all, if knowledge would be futile apart from action, action would be blind without knowledge. What characterizes human action, at least, is its dependence on an *objective* use of sensory data. Sensations are used as indicators of the presence of objects, the behavior of objects, and the interrelations of different objects, and human action is based on this objective knowledge of the world. So we are going to follow up our study of sensation by studies of the processes of observing objects and thinking about them.

EXERCISES

1. Make a list of the senses, and under each list its elementary sensations (as far as identified), and list also a few important blends.

2. In what ways is the eye superior to the ear, and in what ways is the ear superior?

3. What sense besides sight, smell and hearing can sometimes serve as a distance receptor?

4. Count the eye movements of another person who is reading and find how many pauses he makes per line of print.

5. Try to read, to see colors, and to see movement in indirect vision; and discuss the limitations and the value of indirect vision.

6. Show that certain statements about white and black that are true of the physics of light are not true of the response of the organism to light, i.e., are not true psychologically.

7. How could the red and green used for traffic signals be slightly modified so as still to appear fairly red and green to the normal eye and yet to be easily distinguished by the red-green blind eye?

8. Describe and localize the sensations felt in the joints, bones, or muscles, when (a) the knuckles are tapped with a pencil, (b) in walking, and (c) in bending the neck in various directions. Do you seem to get any semicircular canal sensations in any of these experiments?

9. Use the facts of color-blindness as evidence in discussing the question whether sensations come to us, or are our response to stimuli.

10. Why do you think that hearing, touch, pain, and the muscle sense could be called mechanical senses, while taste, smell, and sight were called chemical senses? Where would you classify the internal ear, apart from the cochlea?

11. Separation of taste and smell. Compare the taste of foods, etc., when the nostrils are held closed and when they are open.

12. Touch adaptation. Support two fingers on the edge of a table, and lay on the back of them a match or some other light object. Let this stimulus remain motionless, and notice whether the touch sensation persists unchanged. Notice also the effect of slight movements of the fingers on the strength of the sensation, and explain this effect.

13. Compare the sensory adaptation described in the present chapter with the "negative adaptation" mentioned in the chapter on learning.

14. Work out a list of pairs of complementary colors by the after-image method: have various strong colors for stimuli, fixate each one for about half a minute and then turn the eyes upon a gray background.

15. Write an essay on the importance of the muscle sense, going beyond the material of this chapter and giving concrete illustrations.

REFERENCES

If the subject seems difficult, advantage may be gained by consulting the rather full treatments given by J. B. Watson, *Psychology from the Standpoint of a Behaviorist*, 1924, pp. 48–118; by J. F. Dashiell, *Fundamentals of Objective Psychology*, 1928, pp. 79–118; H. C. Warren, *Human Psychology*, 1919, pp. 151–214; or the much fuller treatment by E. B. Titchener, *Textbook of Psychology*, 1909, pp. 46–224.

Besides the books cited in the footnotes, the following special treatments may be noted: J. H. Parsons, *An Introduction to the Study of Colour Vision*, 1924; R. M. Ogden, *Hearing*, 1924; H. Henning, *Der Geruch*, 1916, on smell; H. L. Hollingworth and A. T. Poffenberger, *The Sense of Taste*, 1917; and M. Luckiesh, *Light and Work*, who considers the sense of sight from the practical standpoint of an engineer.

CHAPTER IX

OBSERVATION

ATTENTION AND PERCEPTION: THE DISCOVERY OF FACTS PRESENTED TO THE SENSES

The senses give us pressure, temperature, movement and resistance, tastes, odors, colors spread out in spatial forms, tones and noises; but the world as we come to know it consists of objects with certain characteristics, behaving and interacting in various ways. The senses do not *give* us these objects. Knowing the objects requires some further response beyond receiving stimuli from them. Observation means the process of coming to know objects by use of the senses.

There are two steps in observation, which may be called *attention* and *perception.* Attention is preparatory to perception. Attention brings the observer into the presence of a fact, and perception consists in his grasping or knowing the fact. Attention explores, perception discovers. Columbus, first exploring westward, then discovering America, shows on a grand scale the same steps that are present in miniature whenever we first look towards something that has caught our eye and then see what is there.

THE ATTENDING RESPONSE

"Attention!" shouts the officer as a preliminary to something more specific, and the athletic starter calls out "Ready!" for a similar purpose. Both commands put you in an attitude of readiness for what is coming next. They arouse a *set* of

the individual that shuts out miscellaneous stimuli and responses, and clears the decks for what the officer, or starter, is going to say next. This preparatory set or readiness is the essential response in attending.

The motor response in attending. Two sorts of motor reaction occur in attention: the general attentive attitude, and the special adjustments of the sense organs. An audience absorbed in a speech or musical performance gives a good picture of the general *attentive attitude*. You notice that most people look fixedly towards the speaker, and that many of them lean forward as if it were important to get just as close as possible. All the little restless movements cease, so that you could "hear a pin drop," and at the tensest moments even the breath is checked. The attitude of attention is one of tense immobility, with the whole body oriented towards the object of attention. When the object of attention is something not present but thought of, a somewhat similar rigid attitude is assumed; the body is apt to lean forward, the neck to be held stiff, and the eyes to stare at vacancy, i.e., to be fixed on some convenient object as a mere resting place, while attention is fixed outside the visual field altogether.

But the motor response of attention includes more than the immobile attitude of readiness; it includes also responses of a mobile and shifting type. The exploratory character of attention shows itself in *sense organ adjustments,* which enable the individual to get stronger and clearer sensations from the object that has aroused attention. Attention to an object in the hand is shown by feeling of it, to something in the mouth by tasting movements, to an odor by sniffing movements, to a sound by a horse's pricking up his ears or by a man's cocking his head and turning his eyes towards the source of sound. The eye movements in attention are elaborate and instructive. The eye is focussed on the object by the action of the ciliary muscle adjusting the lens to the distance of the object, and

the two eyes are converged upon the object, so that the light from it strikes both eyes at the fovea or center of clear vision. If the object is in motion, the eyes fixate it by the pursuit movement, and if it is still, they jump to it and fixate it by stopping on it.

The shifting of attention. These eye movements afford a good picture of the mobility of attention. Ordinarily the eyes shift at short intervals from one part of the field of view to another. When exploring a scene, they shift about in what seems an indiscriminate way, as one object after another catches the attention. In reading, they have learned to move consecutively along the series of words, instead of shifting irregularly about the page.

A moving object, or an object that is doing something, or even a complex object that presents a number of parts to be examined in turn, can hold the eye for some time. But it is almost impossible to hold the eye fixed for any length of time on a simple, motionless, unchanging object.

Attention is mobile because it is exploratory; it continually seeks something fresh for examination. In the presence of a complex of sights and sounds and touch stimuli, it tends to shift every second or two from one part of the situation to another. Even if you are lying in bed with your eyes closed, the movement of attention still appears in the rapid succession of thoughts and images.

A simple experiment will serve to throw the shifting of attention into clearer relief. Look fixedly at a single letter written on a blank sheet of paper, and notice how one part after another of the letter stands out; notice also that attention does not stick absolutely to the letter, since thoughts obtrude themselves at intervals.

A different kind of shifting appears in what is called "fluctuation of attention." Make a light gray smudge on a white sheet of paper, and place this at such a distance that the gray

will be barely distinguishable from the white background. Looking steadily at the smudge, you will find it to disappear and reappear periodically. Or, place your watch at such a distance that its ticking is barely audible, and you will find the sound to go out and come back at intervals. The fluctuation probably represents periodic fatigue and recovery in the parts of the brain concerned in observing the faint stimulus. It is akin to the oscillations in level of work that are found in a continued task which the worker constantly tries to do as well as possible. Such fluctuations as these are changes in the level of brain activity, while the shifting of attention is an entirely different thing. While the fluctuations may have a period or wave length of twenty seconds or more, the shifts of attention take place at a much shorter interval, from a fifth of a second at the shortest up to a second or two. The shifting represents the movement of attention from one object to the next.

The shifting of attention is not entirely a motor affair. Looking at a spot of color, you may attend first to its color, then to its shape; listening to a tone, you may attend first to its pitch and then to its loudness, without any need for altering the position of the eyes or head. You can attend to an object off to the side of the point you are looking at, without turning your eyes towards it. The sequence of thoughts, too, is a non-motor shifting, as far as we know.

THE STIMULUS, OR WHAT ATTRACTS ATTENTION

Though we can attend to anything whatever, we are more likely to attend to some things than to others. As stimuli for the attending response, some objects are more effective than others, and the question is, in what way one object has the advantage over another. There are several ways, several *factors of advantage*, as we may call them.

Change is the greatest factor of advantage. A steady noise

ceases after a while to be noticed, but let it change in any respect and immediately it arrests attention. We become adapted to the steady clicking of the clock, but " wake up " with a start if it stops. This is a sudden change, and any change must have a degree of suddenness in order to attract attention. The change may be one of intensity, a becoming suddenly stronger or weaker; or it may be a change in the quality of a tone or color or odor; or it may be a change in position, a visible or feelable movement. When one who is holding our arm gives it a squeeze to attract our attention, that is a change of intensity; when we step from the shore into the water, the sudden change from warmth to cold, that gets our attention without fail, is a change of quality; and anything crawling on the skin attracts attention by virtue of its motion. Anything moving in the field of view is also an effective stimulus for attention.

Strength of the stimulus is another important factor of advantage. Other things being equal, a strong stimulus will attract attention before a weak one. A loud noise has the advantage over a low murmur, and a bright flash of light over a faint twinkle.

In the case of visible objects, *size* has about the same effect as intensity. The large features of the landscape are noticed before the little details.

Repetition is a similar factor. Repeat a cry or call several times, and after a while it may be noticed, though not at first. Repeat a " motive " in the decoration of a building, and it becomes more impressive than if used only once. The summation of stimuli has much the same effect as increasing the intensity of a single stimulus.

If, however, a stimulus is repeated or continued for a long time, it ceases to hold the attention, because of its monotony. It yields its hold on attention to some other stimulus having the advantage of change and novelty.

Striking quality is an advantage, quite apart from the matter of physical intensity. Saturated colors, though having less intensity of light than pale colors, are stronger stimuli for attention. High notes are more arresting than low. Itch, tickle and pain get attention in preference to a broad, smooth touch. What shall be striking and impressive depends on the organism, and cannot be defined in purely physical terms.

Definite form has the advantage over what is vague. A sharply defined object, even though small in size, stands out from its background and attracts the eye more than a broad, indefinite expanse of light such as the sky. In the realm of sound, definiteness of form is illustrated by tunes and rhythms and by the jingles that so fascinate the child.

The factors of advantage so far mentioned do not depend on previous learning, but stand for natural or "unconditioned" stimuli for attention. There are other factors of advantage that do depend on previous learning and experience. The individual learns what is worth noticing, and what is not, and thus forms habits of attention and of inattention. The automobile driver learns to attend to the sound of his motor, because it indicates whether the motor is laboring or missing or running nicely. The botanist becomes attentive to such very inconspicuous objects as the lichens on the tree trunks. On the other hand, every one learns not to notice repeated stimuli that have no importance for him — an instance of negative adaptation.[1] Move into a house by the railroad, and at first you notice every train that passes, and even at night awake with a start from a dream that some monster is pursuing you; but after a few days the trains disturb you very little, night or day. The general rule covering these learned factors of advantage is this: anything that means anything to you, because you have to work with it or like to play with it, becomes a conditioned stimulus for your attention, while any-

[1] See page 161.

thing that means nothing to you loses whatever hold it naturally had by virtue of its strength or suddenness.

Besides the natural factors of advantage, and besides the factors that depend on previous learning and experience, there are still other factors dependent on the momentary condition of the individual, on the activity he has in progress, on his desire or interest at the time. Stimuli in line with the momentary interest catch attention more than they would at other times, while stimuli out of line with that interest escape attention. What you shall notice in the store window depends on what you are looking for as well as on the prominence of the different objects in the total display. When you are angry or disgusted with a person, you notice bad points that do not usually impress you. The desire or interest of the moment motivates attention, facilitating attention to certain stimuli and inhibiting attention to others, and is thus an important factor of advantage.

The interest of the moment is often represented by a question in your mind. Ask yourself what spots of red there are visible, and immediately various red bits jump out and strike the eye; ask yourself what pressure sensations you are getting from the skin, and immediately several obtrude themselves. A question adjusts attention for whatever may furnish an answer.

The direction of attention is often determined by the influence of other people. What the child shall notice depends largely on what is pointed out to him, and so he becomes acquainted with the same things that other people know. Thus social influences standardize or regularize the knowledge which each individual acquires of the world.

The psychology of attention is of practical concern to the advertiser. Street signs quite obviously use the various factors of advantage. Illustrated signs bid for attention by strength of stimulus, and signs that flash on and off use change

and repetition. Definite form is always in evidence, and often vivid color; and the big signs outbid the little ones. Newspaper and magazine advertisements, in competing for the reader's attention, struggle to utilize all possible factors of advantage. Psychological experiments have shown that doubling the size of an advertisement falls short of doubling the number of readers whose attention it will catch, though it does increase that number considerably (by 40 or 50 per-cent); also that repeating an advertisement increases its attention value, especially if a certain amount of variation is combined with the repetition, to avoid monotony. More important, perhaps, than these mechanical devices is the appeal to habitual or temporary interests of the reader. If one is hunting for a job, even a little "want ad," with all the factors of advantage against it, except the factor of momentary interest, will surely catch the eye.[2]

SUSTAINED ATTENTION

Sustained attention does not mean a sort of cramp that keeps attention glued to a point. It means, rather, that attention, instead of wandering here, there and everywhere, remains on a certain object, or within a certain field, while still moving within that field.

Eye movement, which gave us a picture of the shifting of attention, also indicates the nature of sustained attention. Remember how the eye moves in reading. Every second it shifts, but still it keeps to the line of print. Attention keeps moving forward in the story we are reading, but sticks to the story. The more absorbed we are in the story, the more rapidly we read. Attention is sustained here, and still it moves.

[2] On the attention value of advertisements, see H. F. Adams, *Advertising and Its Mental Laws*, 1920, and A. T. Poffenberger, *Psychology in Advertising*, 1925.

What is it, then, that sustains attention? Evidently it is the factor of present desire or interest, only that the desire or interest lasts, and continues its facilitating and inhibiting effect. The unanswered question, or the unsolved problem, is one source of sustained interest that limits the field within which attention moves.

In serious reading, you need an interest or problem to carry you along. We can learn something here from story-reading, which is the most efficient sort of reading, in the sense that you get the point of the story better than that of more serious reading matter, the reason being that attention is always pressing forward in the story, looking for something very definite. You want to know how the hero gets out of the fix he is in, and you press forward and find out with great certainty and little loss of time. The best readers of serious matter have a similar eagerness to discover what the author has to say; they get the author's question, and press on to find his answer. Such readers are both quick and retentive. The dawdling reader, who simply spends so much time and covers so many pages, in the vague hope that something will stick, does not remember the point because he never got the point, and never got it because he wasn't looking for it.

Development of attention. For the student, the ideal attention-sustainer is an interest in the matter presented. If, however, he cannot get up any absorbing interest in the subject-matter at once, he may generate the necessary motive force by taking the lesson as a "stunt," as something to be mastered, a spur to his self-assertion. In the old days, fear was often the motive force relied upon in the schoolroom, and the switch hanging behind the efficient teacher's desk was the incentive for sustained attention. Some extraneous motive is often required to carry the beginner far enough into the subject so that he can discover its inherent interest.

So, when the little child is learning to read, the printed char-

acters have so little attractiveness in themselves that he naturally turns away from them after a brief exploration. But, because he is scolded when his mind wanders from those marks, because other children make fun of his blunders, because, when he reads correctly, he feels the glow of success and of applause, he does hold himself to the printed page till he is able to read a little, after which his interest in what he is reading is sufficient, without extraneous motives, to keep his nose between the covers of the story book more, perhaps, than is good for him. The little child, here, is the type of the successful student.

Attention to a subject thus passes through three stages in its development. First comes the random sort of attention, excited by novelty and change, size and the other unlearned factors of advantage. Next comes the stage of forced attention, driven by extraneous motives, such as fear or self-assertion. Finally arrives the stage of objective interest. In the first and last stages attention is spontaneous, in the middle stage forced. The middle stage is often called that of voluntary attention, since effort has to be exerted to sustain attention, while the first and last stages, being free from effort, may be called involuntary.

Distraction. A distraction is anything that works against sustained attention, by competing for attention with some factors of advantage on its side. A person who has no strong interest in what he is doing, or one who has something else in mind that he would much prefer to do, or one who is not negatively adapted to the noises and other distracting stimuli that reach him, is for the time being a distractible person.

In the insane condition known as the "manic state," or "manic excitement," the patient is excessively distractible. He commences to tell you something, all interest in what he has to say, but, if you pull out your watch while he is talking, he drops his story in the middle and shifts to some remark about the watch. He seems to have no interest persistent

enough to hold his attention steady. In the contrary "depressed state," which the same individual may get into at another time, it is almost impossible to distract him, so absorbed is he in brooding over his own troubles. Thus the same individual may be at one time very distractible, at another time quite the opposite; and we do not know as yet what is the cause of this change.

Distraction is a favorite subject for experiment in the laboratory, for the light it throws on sustained attention. We have already described a distraction experiment [3] which revealed the subject as overcoming the distraction by putting extra effort into his work. There are several ways of overcoming a distraction. First, greater energy may be thrown into the task one is trying to perform. The extra effort usually shows itself in gritting the teeth, reading aloud, and similar muscular activity, all useless for executing the task in hand, but somehow helping to keep the organism's energy within the task. Second, one may form a habit of inattention to an often recurring distraction, and come to disregard it without effort. Third, there is a very different way of dealing with a distraction, which works very well in certain cases, and that is to couple the distraction to the main task. An example is seen in piano playing. The beginner at the piano likes to play with the right hand alone, because striking the bass note with the left hand distracts him from striking the tune with his right hand. But, after practice, he couples the two hands, and strikes the whole chord at once, much to his satisfaction. Coördination here is essentially the same thing that we noticed before in connection with conflicting motives.[4]

SELECTIVITY OF ATTENTION

Though we have not said it in so many words, all that we have said implies that attention is a selective response. There are always several or many stimuli competing for the indi-

[3] See page 263. [4] See page 272.

vidual's attention, but only one of them catches his attention at a given moment. He may shift a moment later to another stimulus. Attention, in short, obeys the laws of reaction which were formulated on the basis of reflex action.[5] The law of selection stated that " of two or more inconsistent responses to the same situation, only one is made at the same time." From the fact that this law applies to attention, we can infer that attending to one stimulus is inconsistent with simultaneously attending to another stimulus.

However, the single stimulus that gets attention need not be a simple stimulus. It may be as complex as the taste of lemonade or the sound of a chord or the sight of a tree. Thus the law of combination comes into play.

Doing two things at once. The law of selection brings to mind the question that is often asked, " Can any one do two things at once? " In this form, the question admits of but one answer, for we are always doing at least two things at once, provided we are doing anything else besides breathing. We have no trouble in breathing and walking at the same time, nor in seeing while breathing and walking, nor even in thinking at the same time. But breathing, walking, and seeing are so automatic as to require no attention. The more important question, then, is whether we can do two things at once, when each demands careful attention.

Julius Cæsar, it is said, used to dictate at once to several copyists. Now, as Cæsar's copyists were not stenographers, what he had to do was to give the first copyist a start on one letter, then give the second a start on another letter, and so on, getting back to the first in time to keep him busy. Quite an intellectual feat, certainly! But not a feat requiring absolutely simultaneous attention to several different matters. In a small way, any one can do something of the same kind. You can add a column of numbers while reciting a familiar

[5] See page 233.

poem; you get the poem started and then let it run on automatically for a few words while you add a few numbers, switch back to the poem and then back to the adding, and so on. But in all this there is no doing of two things, attentively, at the same instant of time.

Definite experiments on doing two things at once, such as adding columns of numbers while listening to a story which one has to reproduce afterwards,[6] show that the subject does shift back and forth between the two tasks. He loses the story from time to time, but pieces it together as well as possible. If the adding is very easy for him, he may do it almost automatically, and have most of his attention for the story. But he never adds as efficiently as he would if not listening to the story, and he never hears the story as well as he would if not adding. On the average, and with great individual differences, he does about 60 per cent. as well in these simple tasks combined as he would in performing them separately. Even a task so simple as writing "+ — + — + —," and so on, disturbs the following of the story. On the other hand, a *postural* performance, involving *muscular tension* — such as giving a moderate steady squeeze to each of two dynamometers held in the hands — gives an increase, instead of a decrease, in the performance of a simultaneous mental task, such as adding or memorizing.[7] This last result reminds us of the stimulating effect of auditory distractions, when overcome by extra effort, and also suggests that the involuntary muscular tensions of jaw, brow, neck, hands, body and legs, which so regularly accompany intense mental effort, may have a genuine stimulating effect upon mental activity. However, the matter is not altogether simple, from the practical point of view, for it has also been found that adding and

[6] O. Sterzinger, *Zeitschrift für angewandte Psychologie*, 1928, vol. 29, p. 177.

[7] A. G. Bills, *American Journal of Psychology*, 1927, vol. 38, p. 227.

memory tasks are better performed in a lying than in a standing position; and inquiry among eminent writers showed that a large number, probably well over half of them, were accustomed to recline, put their feet on the table, or otherwise adopt an approximately horizontal position, when doing their most active mental work.[8] The horizontal position favors brain circulation. There is also some evidence, not experimental however, that the most efficient brain workers get along with a minimum of muscular tension. Many habits of brain workers — preferred hours of the day, place of work, position, and accessories — are probably just habits, without any compelling physiological basis. Evidently the conditions of effective mental work are complex, but concentration of attention, and freedom from distraction and from incidental performances, are no doubt favorable on the whole.

Degree of consciousness as related to attention. We are more conscious of that to which we are attending than of anything else. Of two stimuli acting at once upon us, we are the more conscious of that one which catches our attention; of two acts that we perform simultaneously, that one is more conscious that is performed attentively.

We need not be entirely unconscious of the act or the stimulus to which we are not attending. We may be dimly conscious of it. There are degrees of consciousness. Suppose, for example, you are looking out of the window while lost in thought. You are most conscious of the matter of your thoughts, but conscious to a degree of what you see out of the window. Your eyes are focused on some particular object outside, and you are more conscious of this than of other objects seen in indirect vision, though even of these last you are not altogether unconscious. Consciousness shades off from high light to dim background.

The "field of attention" is the maximum or high light of

[8] E. E. Jones, *Archives of Psychology*, no. 6, 1907.

consciousness; it comprises the object under attentive observation, the reaction attentively performed. The "field of consciousness" includes the field of attention and much besides. It includes objects of which we are vaguely aware, desires active but not clearly formulated, feelings of pleasantness or unpleasantness, of tension, excitement, confidence, etc.

Apparently the field of consciousness shades off gradually into the field of unconscious activity. Some physiological processes go on unconsciously, and very habitual movements may be almost or entirely unconscious. The boundary between what is vaguely conscious and what is entirely unconscious is necessarily very vague itself, but the probability is that the field of consciousness is broader than we suspect, and includes many activities that we think of as unconscious. We shall return to the fascinating topic of the unconscious in the last chapter.

Degree of consciousness does not always tally with intensity of sensation or energy of muscular action. One may be more conscious of a slight but significant sound — like the faint cry of the baby upstairs — than of much louder noises occurring at the same time. One may be more conscious of a delicate finger movement than of a big movement like walking. The factor of interest, in such cases, favors the weak stimulus.

It is not always the most efficient process that is most conscious; indeed, practicing an act makes it both more efficient and less conscious. The less efficient processes require attention because they tend to go wrong.

Evidently degree of consciousness does not go with bigness of total performance. When the organism is executing two performances at once, the smaller of the two may be the more conscious. How can this be? Probably degree of consciousness goes with brain activity, rather than with activity elsewhere in the organism, and probably executing a precise finger movement occupies the brain more than walking does. In

the same way, hearing a faint but significant sound probably requires more brain action than hearing a loud, continued sound that has no importance.

ATTENTION AND PERCEPTION

Thus far, this chapter has considered the preliminary stage in observation. Attention is getting ready to see what is there. When you are prepared, you observe facts that you would otherwise have overlooked, and your observation is more dependable, being focussed beforehand on the exact point which you wish to know.

We are not to think of attention as preparing all at one time for a long period of observation. Attention, as we have seen, keeps moving on and on, and discovery of new facts is always just a step behind. When we say here, "discovery of new facts," we mean new for the individual, or even simply new in the situation that the individual is observing. You enter a company of friends, and your first question is, "Who's here?" One face after another catches your attention, and you note the fact (a new fact, a discovery, though a modest one) that A is here, and B and so on. Adding fact to fact, you soon build up a knowledge of the present situation.

To perceive means literally to grasp. "Grasping a fact" is obviously a figure of speech which tells us nothing of what goes on in observing facts. "Apprehend" is another synonym. If we want to avoid figurative expressions, we can substitute the word "know"; but "know" is the name of a result or achievement, and not of a process. To perceive is to know facts presented to the senses; but the process of perceiving we shall have to study in some detail before attempting to give a general description of it.

Of the processes studied up to this point, the one most in line with perception is recognition. To recognize an object is to perceive it as such and such a known object. But we

cannot hope to explain perception as a kind of recognition; for to recognize an object now, we must have observed it previously. Recognition is based on perception, and perception is the more fundamental process of the two. Perception is not wholly a learned or conditioned response. It is primarily an unlearned response, though very susceptible to the influence of learning. What you shall see depends only in part on previous experience. Perception is like attention so far, since what you shall attend to depends partly on your habits of attention, but partly also on the relative strength, novelty, etc., of the various stimuli that are competing for your attention.

The general laws of reaction, so well illustrated by attention, are equally present in perception. Perception is selective — you turn to an object to see what is there, and you see *some* of what is there to be seen. Perception shifts — you hold your attention upon an object and you keep seeing something more and different about it. Perception is subject to the law of advantage — one fact is more easily seen than another, even though both are equally present to the eye. And perception is subject to the law of combination — it responds to combinations of stimuli, and sees groups and totals more easily than elements.

FUNDAMENTAL CHARACTERISTICS OF PERCEPTION

Some of the fundamental facts of perception, facts that indicate *how* we perceive, are brought out strikingly in the study of little drawings and designs. Instructive experiments on this subject can be performed with no more elaborate apparatus than a pencil and a blank sheet of paper. The results obtained in this simple way have been checked up by more careful laboratory experiments.

Figure and ground. If you first draw a two-inch square on your paper, to serve as a sort of frame, and then draw a much

smaller square inside of this frame, and if you then simply look at what you have drawn, usually the little square stands out as an object against the background of the enclosing white space. But if you draw the inside square almost as large as the outer square, and parallel to it, then what stands out as the figure is the double square, and the white space inside appears as the background. The figure has form, the ground seems like indefinite space. The figure usually seems to stand out towards you, and the background to extend around behind the figure.

In another square frame, shade in a small portion, not necessarily regular in shape. The dark part then appears as the figure, and the enclosing light part as the ground. For comparison, shade in all of another square except for a small portion, and then the light part appears as the figure against a dark ground.

What shall be seen as figure and what left as ground depends on many conditions, some of which will be brought up later under the head of factors of advantage in perception. We can see already that the figure is apt to be compact. It hangs together by virtue of its compactness. But it may be comparatively large, provided it has a definite shape that holds the parts together. In the ordinary use of the eyes, figure and ground are much in evidence. We almost always see some object or shape against a background which appears as relatively uniform and unfigured. It is not true, however, that objects in the background, or to the side, lose all their figure. More than one figure may be seen at the same time, some standing out more clearly than others. So the distinction between figure and ground is not the same as that between the field of attention and the rest of the field of consciousness. You can attend to the ground in any of the drawings used in this experiment, but you are certainly much more apt to attend to the figure.

Figure and ground are nicely illustrated, in the auditory field, by the tune and the accompaniment in music. The tune, air or melody stands out as figure from the tonal ground of the accompanying chords. If, however, the accompaniment

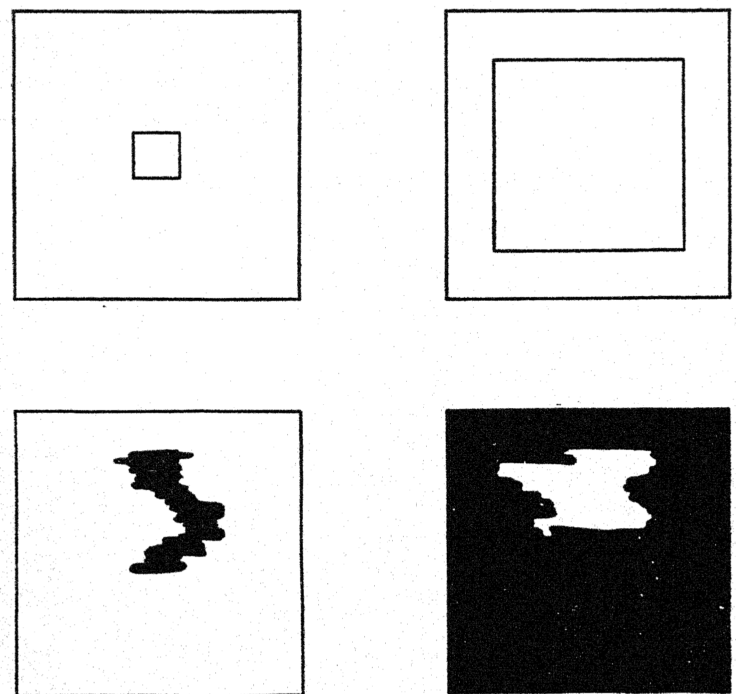


FIG. 40.—Studies in figure and ground.

itself has some tune or rhythm, this secondary figure is heard along with the main tune, and may be combined with it into a compound figure.

Figure and ground show the law of selection operating in the process of perception. The mass of sensations is not seen or heard unselectively or just as a plain mass, but always some figure is discovered in the mass.

The span of apprehension. Somewhat akin to the memory span that we heard of before, the span of apprehension is the answer to the question, how many objects we can perceive at once. Measurement of this span is one of the oldest experiments in psychology, made at first with very rough apparatus. Some one places a few marbles in a box, you take a single peek and tell, if you can, how many are there, not guessing but knowing. The span measures about four or five, if no errors are allowed.

In the laboratory we have exposure apparatus that displays a card for a fifth of a second or less, just time enough for a single view and not enough to look the card over. The experimenter prepares many cards, each one containing a number of dots, scattered irregularly over the card, and exposes the cards one at a time; and the subject, being ready for the exposure, attempts to see all the dots, and tell how many there are. If there are only two, three or four on a card, the subject probably reports the number correctly every time; with five, an occasional error can be expected, and the errors increase gradually till at about twelve dots the subject can only guess. Thus the span is a variable quantity, even with the same individual, and it varies from individual to individual.

But how, it may well be asked, can the subject in this experiment see as many as eight or ten dots, with no time allowed for counting one after another? The visual after-image helps sometimes, and the primary memory-image still more. But the most important aid is *grouping*. The irregular assembly of dots is seen in groups. If there are only three or four dots, they form a single group; if there are seven, they probably appear as a group of four and a group of three. Unless the dots do fall instantly into groups, the subject cannot usually tell the number. If the experimenter has grouped them objectively, or arranged them in a regular system, the subject's task is simplified.

If the material exposed, instead of being mere dots, consists of a line of letters, three or four can be clearly read at a glance. If the letters make up familiar words, two or three words can be read at a glance. And if the words make up a familiar phrase, the whole phrase, containing as many as twenty letters, can often be read at a single glance.

The limited span of perception is another indication of selectivity. The eye sees more at a time than the brain can see. The eye furnishes more perfectly good data than the brain can use. It is not because the area of clear vision is limited that the span of apprehension is so small; for the experimenter can easily arrange to present twenty or forty dots within the area of clear vision, but the subject cannot organize so many in a moment. Perception evidently means work, and thus is forced to be selective.

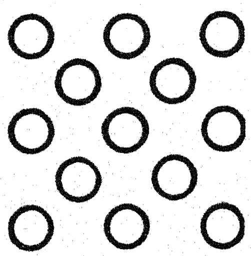


FIG. 41.—A dot figure, from Sanford. Look steadily at it.

If the limited span shows the law of selection, grouping shows the law of combination. Little items like dots or letters do not arouse each its own separate response, but several of them, together, arouse a single response.[9]

Shifting perception. Let us modify our experiment with the dots. Instead of exposing them for only an instant, let us examine them at our leisure; and instead of counting them,

[9] E. S. Oberly, *American Journal of Psychology*, 1924, vol. 35, pp. 332–352.

let us simply look at any assembly of dots, regular or irregular, and notice what groupings and patterns we see. Under these

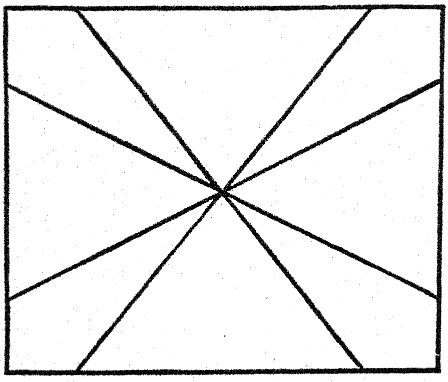


FIG. 42. — (From W. Köhler, *Gestalt Psychology,* published by Liveright, 1929.) A drawing that can be seen in different ways.

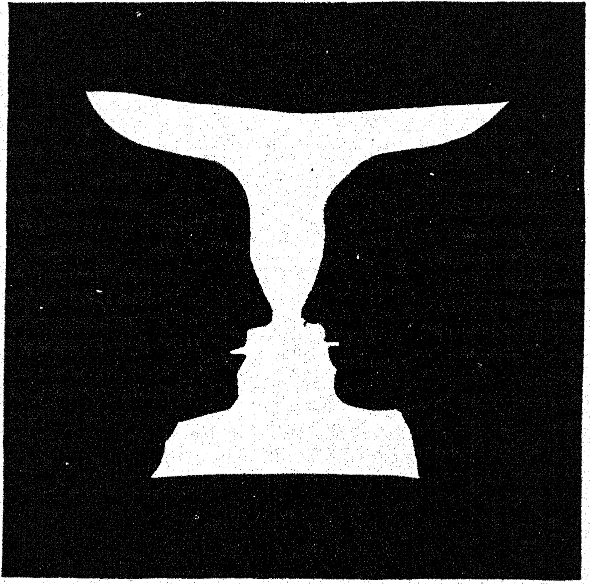


FIG. 43. — (From E. Rubin, *Visuell wahrgenommene Figuren,* 1921.) Figure-ground reversal.

conditions, the most striking phenomenon is the change from one grouping to another. First the dots fall into one pattern, and then, without warning, they shift into a different pattern. The patterns are mutually exclusive; when one comes, the other goes. Now objectively the dots do not change, and therefore the shifting occurs wholly in the observer, and is his response. The objective stimuli arouse grouping responses in the observer, and where more than one such response is easily aroused, the observer shifts from one to another grouping.

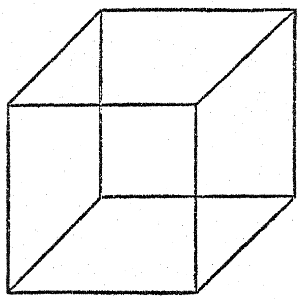


FIG. 44. — The ambiguous cube figure.

Figures that give shifting perceptions can be made of lines as well as of dots. Some shifts amount to an interchange of figure and ground.

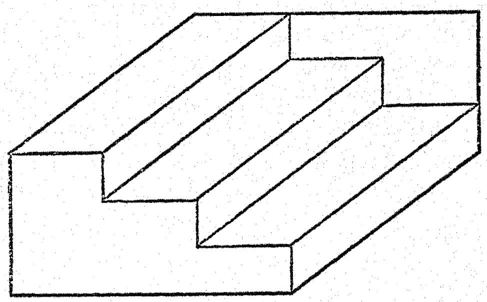


FIG. 45. — The ambiguous staircase figure.

Shifting is especially striking when a drawing is made in ambiguous perspective, so, that is, as to represent a solid body

equally well in two different positions. The transparent cube, showing near and far edges alike, is a good example. Examined steadily, the cube seems to change from time to time; it is seen, successively, in two different ways. Numerous such figures can be drawn, the most celebrated being the ambiguous staircase. Look steadily at this, and suddenly you see the under side of a flight of stairs, instead of the upper, and if you keep on looking, it keeps on shifting between these two appearances. Certain fixation points for the

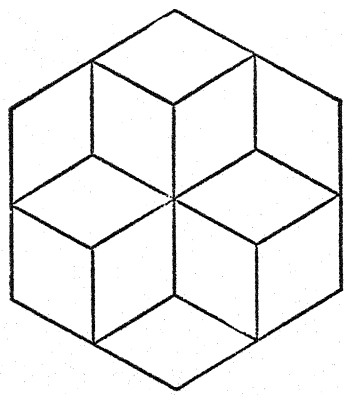


FIG. 46. — Another ambiguous figure. There is really no excuse for seeing anything here but the perfectly good flat figure which probably appears first — no excuse, except our proneness to see solid, three-dimensional objects in all figures that admit of such interpretation.

eye favor one appearance, and other fixation points the other, and yet the appearance does not depend wholly, or mainly, upon the fixation point.

In this connection, we do well to recall once more the remarkable case of shifting that we noticed before under the name of binocular rivalry,[10] which occurs when lines that will not combine into a single meaningful picture are presented to the two eyes. Binocular rivalry shows both selectivity and shifting.

[10] See page 361.

Factors of advantage in the perception of figures and groups. We have had factors of advantage before us before, under the heads of reaction and of attention, but others come to light in the study of perception.

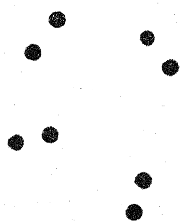


FIG. 47.

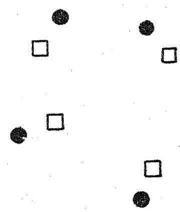


FIG. 48.

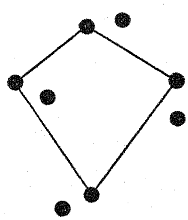


FIG. 49.

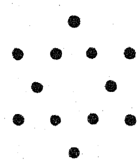


FIG. 50.

FIG. 47. — A dot figure to show proximity as a factor of advantage in seeing figures.

FIG. 48. — A dot figure to show similarity as a factor of advantage in seeing figures.

FIG. 49. — A dot figure to show continuity as a factor of advantage in seeing figures.

FIG. 50. — A dot figure to show inclusiveness as a factor of advantage in seeing figures. This figure contains two hexagons, and also two interlacing triangles, all good figures which may show themselves from time to time, but which are at a disadvantage in competition with the all-including star.

1. *Proximity* of elements favors uniting them into a pattern. This can be seen in irregular dot figures: the groups most easily seen consist of dots that are relatively close together.

2. *Similarity* of elements favors uniting them into a pattern. The same dot figure that showed groups dependent on proximity falls into a different grouping if some of the dots are given a different shape, or color, from the rest, for the similar

dots tend to be seen as a group, and two interlacing groups may thus appear.

3. *Continuity* of pattern is a factor of advantage. Continuity may be lugged in by faint lines tying certain of the dots together, or it may be provided by the arrangement of the dots themselves.

4. *Inclusiveness* of a pattern is a factor in its favor, as against other patterns which would otherwise have the advantage. If all the elements fall readily into a single group, that pattern has the advantage; if they do not, the pattern consists of two or more groups, or of a group with stragglers left outside.[11]

A critical reader, remembering all that can be accomplished by learning and "conditioning," and disposed to minimize the unlearned element in behavior, may well raise the question whether the laws of perception thus far stated are really primary. He may suggest, for example, that dots that are close together are seen as belonging together, just because long continued experience has familiarized us with innumerable small, compact objects, the parts of which we have found to belong together. But such a view is vague, and can scarcely hold of extreme cases. To ask us to believe that two points lying far apart in the field of view could just as easily be grouped together as two points that are close to each other — or to ask us to believe that two drum beats separated by half a minute in time could just as easily be grouped as two that are only a second apart — is asking a little too much. While much needs to be done in the genetic study of perception, we may take it as probable there are a few fundamental characteristics of perception, which are not drilled into us by learning. The fundamental characteristic of all is that groups, patterns and figures are more readily perceived than separate

[11] References: M. Wertheimer, *Psychologische Forschung*, 1923, vol. 4, p. 301; W. Kohler, *Gestalt Psychology*, 1929, pp. 148–223.

elements. Perception is a combining activity, as well as selective.

In order, however, not to neglect the importance of previous learning in perception, let us add another to our factors of advantage, namely that:

5. *Familiarity* of a pattern or object gives it the advantage over others that are less familiar. Picking out a circle or a

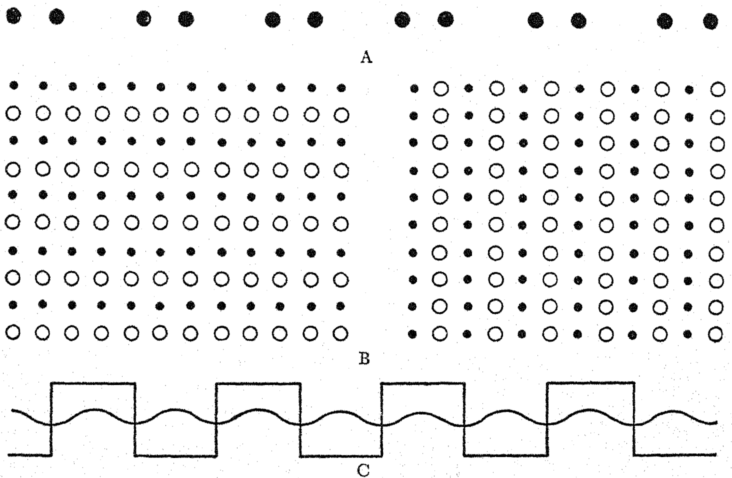


FIG. 51. — (From Max Wertheimer, *Psychologische Forschung*, 1923.) Other dot figures, showing the influence of proximity, of similarity, and of continuity, in determining what groups and figures shall be most readily seen. In A, you may be able, by great effort, to tear apart the pairs consisting of dots that are close together, and see instead pairs composed of adjacent dots that are further apart; but certainly ease of perception favors pairing the dots that are close together. In B you can by effort see rows and columns not composed of similar elements, but grouping similars is the line of least resistance. In C it would take great effort indeed to attach parts of the wavy line to parts of the angular line, so as actually to *see* a design built up of these discontinuous parts.

human profile from a mass of lines is made easier by the familiarity of these figures. We should also add that:

6. The *set* or *readiness* of any moment is a factor in determining what shall be perceived at that moment. If you are

all set to see a certain pattern or object, or to hear a certain rhythm, that pattern has the advantage over others equally familiar or compact.

Puzzle pictures prove that familiarity and readiness are not the *only* factors operating, since often you simply cannot find the hidden face, though you are all set for faces, and though faces are certainly familiar enough. What conceals the face is the advantage possessed by the other figures that you do see, an advantage due partly to the primary factors already mentioned, and partly to yet another factor, perhaps as important as any. The whole picture in which the face is hidden is a coherent whole, while the hidden face is but an isolated fragment. You have to lose sight of the coherent whole in order to see the face. So we have our final factor of advantage, which undoubtedly belongs among the primary factors.

7. The *whole that is perceived* gives the advantage to parts coherent with that whole. Parts are perceived as belonging to the whole, rather than separately. This factor is perhaps the same as that of continuity, mentioned above; only that here we stress the whole pattern or object or situation as determining how the parts shall be perceived. In perception, at least, there is much truth in the saying that the whole determines the parts.

OBSERVATION OF DETAILS

Thus far, though we have indeed spoken of perception as a selective response, our emphasis has been on grouping and combining. This emphasis needs to be balanced by pointing out the fact that perception is always an *isolating* response as well. We see a figure as a total, but at the same time the figure stands out from its background, and to that extent is isolated from the mass of sensations occurring along with it. We perceive a face — that means that we take the face as a

unit, isolating it from its background. If we examine the face in detail, we may isolate the nose and perceive that as a whole. We might go still further in the direction of isolating details, and perceive a freckle on the nose. Even if we went so far as to observe a single speck of dust on the skin, in which case isolation would about reach its maximum, combination would still stay in the game, for we should notice the position of the speck, thus relating it to the general pattern of the face, or we should notice its color in contrast with the color of the skin, or in some other way we should bring the speck into relation with something else. Isolation can go a long way, but always by combining the isolated fact with some other fact.

Motivation of analytic observation. As general patterns are easier to observe than fine details, why do we ever make the effort to analyze out the details? Largely because the unanalyzed total impression does not work well. First impressions of a new acquaintance often need revision if we have to deal practically with that person. They do not work well because they have overlooked details which prove to be important. Trial and error often take place in the sphere of observation. When our first general impression of an object gets us into difficulties, we are forced to look more closely. The child at first treats gloves as alike, whether rights or lefts, but cannot manage them on that basis and so is driven to look at them more sharply.

The average non-mechanical person, on acquiring an automobile, takes it as a gift of the gods, a big total thing, simply to sit in and go. He soon learns certain parts that he must deal with, but most of the works remain a mystery to him. Then something goes wrong, and he gets out to look. "What do you suppose this thing is here? I never noticed it before." Tire trouble teaches him about wheels, engine trouble leads him to know the engine, ignition trouble may lead him

to notice certain wires and binding-posts that were too inconspicuous at first to attract his attention. A car becomes to him a thing with a hundred well-known parts, instead of just one big totality.

SIGNS AND MEANINGS

In our discussion of the fundamental characteristics of perception, we did not mention one characteristic that is certainly important enough to be called fundamental. What we usually observe is not simply groups and patterns, but things and other *objective facts*. A little red figure on a green ground catches the eye, and we see — a ripe strawberry. A certain pattern of noises reaches the ear, and we hear a dog barking. Sense perception is knowing facts that are presented to the senses. But the facts that we perceive are often not fully presented; they may be merely indicated. We may have before the eyes simply a *sign* of some fact, but perceive the fact which is the *meaning* of the sign. We look out of the window and "see it is wet today," though wetness is something to be felt and not seen. What we see is some sign of wetness. We use many similar expressions which are absurd if taken literally. We "hear the street car," though a street car is not a noise, and we say that a stone "looks heavy," or that the jar of fruit "smells sour." Thus one sense affords signs of facts that could only be really experienced by another sense.

Signs and their meanings have to be learned — no doubt of that! The "fundamental characteristics of perception" that we spoke of before as probably unlearned determine what figure or pattern we shall see in the medley of stimuli received, but what the figure or pattern means, objectively and practically, we have to learn. Sign and meaning are connected by learning. For Pavlov's dogs, the bell regularly followed by food became the sign of food. In the same way, the child sees a bit of the ground that looks peculiar, he steps there and

finds a puddle; and that visual appearance thus becomes the sign of wetness.

Reduced cues in perception. The principle of reduced cues was found to be important in recall and recognition, in our early chapter on memory. Now, so far as perception depends on previous learning, it must consist in recall and recognition, and accordingly we may expect to find reduced cues here again. A cue is of course a stimulus, and a reduced cue is a stimulus that is less complete than the stimulus that originally aroused the response. Now the stimulus, in learned perception, is the sign that indicates a certain fact, and the response amounts to knowing the fact. A reduced cue in perception, then, is a stimulus that is less than a complete presentation of the fact; and that is just what a sign is.

Examples of reduced cues in perception could be multiplied without limit. The outline drawings of persons, animals, houses, trees, that are common in children's picture books, and that the child understands at an early age, are certainly much reduced from the visual appearance of the real objects. A person or thing seen in the distance presents a much smaller and less detailed picture than when close at hand, but still can be recognized. A child, after seeing and hearing a barking dog needs only one of these senses to indicate the presence of that vociferous animal.

Again, consider how we perceive the real shape of an object, though seen at various angles and therefore presenting various strictly visual shapes. A rectangular door or book cover, seen square on, does present itself as a rectangle to the eye, but seen at any other angle it is visually an oblique figure, and still is perceived as square. If any one who has not been instructed in perspective drawing attempts to draw the door as he sees it, he probably draws it rectangular as he knows it to be. A thing is never twice the same, as a collection of stimuli, and yet, within wide limits, it is always perceived as the

same; for we perceive things as we have learned them to be objectively.

Sensory data serving as signs of various sorts of fact. Now the question arises, by what signs the various objective facts are perceived. Often it is very difficult to tell. We get the fact, but how, we do not know. For example, we can feel of objects with a stick held in the hand, and thus perceive their roughness or smoothness; and it even seems to us as if we felt them with the end of the stick, which is absurd. It must be that we perceive the roughness or smoothness by means of sensations arising in the hand and arm, but to identify these sensations is a much harder task than to perceive the objective fact of roughness.

Again, we distinguish the tones of two musical instruments by aid of their overtones, but elaborate experiments were required to prove this, since ordinarily we do not notice the overtones, and can simply say that the instruments sound differently, and let it go at that.

Once more, consider our ability to perceive time intervals, and to distinguish an interval of a second from one of a second and a quarter. How in the world can any one perceive time? Time is no force that could conceivably act as a stimulus to a sense organ. It must be some change or process that is the stimulus and that serves as the indication of duration. Most likely, it is some muscular or internal bodily change, but none of the more precise suggestions that have been offered square with all the facts. It cannot be the movements of breathing that give us our perception of time, for we can hold our breath and still distinguish one short interval from another. It cannot be the heart beat, for we can beat time in a rhythm that cuts across the rate of the heart beat. When a singer is accompanying himself on the piano, keeping good time in spite of the fact that the notes are uneven in length, and meanwhile using his feet on the pedals, what has he got left to beat

time with? No one has located the stimulus to which accurate time perception responds, though, in a general way, we are pretty sure that change of one sort or another is the datum. With longer intervals, from a minute to several hours, the sign of duration is probably the amount happening in the interval, or else such progressive bodily changes as hunger and fatigue.

PERCEIVING SPATIAL FACTS

Signs of location are provided by all the senses. We perceive a taste as in the mouth, thirst as in the throat, hunger pangs as in the stomach. To stimulation of the semicircular canals we respond by knowing the direction in which we are being turned. The sense of smell, though a distance receptor, tells us nothing of the objective location of the source of an odor, except (1) as we know the odor and so can judge from its intensity something of the distance of the source, and (2) as, by making exploratory movements of the head or body, we track down the source.

The ears, as was said before, give us primarily only the distinction between right and left. But by turning the head in various directions we can locate the direction of sound fairly well. By getting to know the sounds emitted by different objects, and by hearing them at various distances, we come to perceive the distance as well as the direction of the source of sound. By becoming acquainted with echo and resonance — not in a scientific way, but practically — we can even locate sounds as coming from behind walls and buildings. The blind, more than the seeing, utilize echo and resonance for indicating the location of walls, etc., that reflect sound, as well as for locating the sources of sound. Thus, by hook and by crook, we learn to locate sounds surprisingly well.

The remaining senses, the cutaneous, the kinesthetic and the visual, afford much fuller data for the perception of spatial facts.

A cutaneous stimulus is located with fair exactness, though much less exactly on such regions as the back than on the hands or lips.

In handling an object, as also in walking and many other movements, the cutaneous and kinesthetic senses are stimulated together, and between them furnish data for the perception of many spatial facts, such as the shape of an object examined by the hand. The spherical shape is certainly better perceived by this combination of tactile and kinesthetic sensations than by vision, and the same is probably true of many similar spatial facts. That is, when we see the roundness of a ball, the visual stimulus is a substitute for the tactile and cutaneous stimuli that originally had most to do with arousing this perception.

The sense of sight is apparently the best space sense, but it acquires this advantage in part by being used in combination with touch and the muscle sense, in the way just illustrated, and then furnishing signs, or reduced cues, of spatial facts originally discovered by those other senses. Yet we certainly find the eye the most satisfactory sense for locating objects; and, in fact, the visual perception of location is so much more exact than the cutaneous and kinesthetic that it cannot possibly be derived from them. The same is true of the visual perception of size and shape, which is one of the most precise of all forms of perception. The retina, itself, then, affords very complete signs of location and size, as far as these are confined to the two dimensions, up-down and right-left. But when you stop to think, it seems impossible that the retina should in any way indicate the third dimension, or the distance of an object from the eye.

The retina is a screen, and the stimulus that it gets from the world outside is like a picture cast upon a screen. The picture has the right-left and up-down dimensions, but no front-back dimension. How, then, does it come about, as it certainly does,

that we perceive by aid of the eye the distance of objects from us, and the solidity and relief of objects? This problem in visual perception has received much attention and been carried to a satisfactory solution.

A single, motionless eye receives a picture similar to one painted on canvas, and the available indications of distance are the same in the two cases. The painter uses *perspective,* or foreshortening, and makes a man the smaller in the picture the further away he wants him to appear; and in the same way, when any familiar object casts a small picture on the retina, we perceive the object, not as diminished in size, but as far away. The painter colors his near hills green, his distant ones blue, and washes out all detail in the latter — *aërial perspective,* he calls this. His distant hill peeks from behind his nearer one, being partially *covered* by it. His *shadows* fall in a way to indicate the relief of the landscape. These signs of distance also affect the single resting eye and are responded to by appropriate spatial perceptions.

With both eyes in use, we have the *binocular depth effect,* already described under the head of sensation.[12] This is a realistic appearance of solidity in three dimensions, provided the object examined is near. A little experiment demonstrates the superiority of binocular over monocular vision in the perception of distance. Take a pencil in each hand, close one eye, and bring the pencil points horizontally from the two sides till they seem to be almost touching; then open the other eye, and see if you can improve the setting.

If the head is moved from side to side, while the eyes continue to look forward, distant objects seem to move with the head, and nearer objects to slide in the opposite direction. Try this in the woods some time, and see how clearly the nearer and farther branches are distinguished. If you look to the

[12] See page 359.

side from a rapidly moving train or car, the effect is still more pronounced.

All of these signs of distance are utilized together in the visual perception of three-dimensional space, sometimes one sign and sometimes another being more useful. In learning the spatial meaning of these signs, the child is undoubtedly helped by watching objects as they approach or recede from him, or as he approaches them. The chick reacts correctly to distance as soon as hatched, and it is quite possible that some sign of distance, probably the binocular sign, does not have to be learned.

The several senses do not operate independently in perceiving spatial facts, for it is the organism, as a unit, that does the perceiving, utilizing the data from the senses as signs of objective facts, and cross-referencing the signs from different senses so that visual, auditory, cutaneous and kinesthetic space all agree. And the motor responses of eyes, head, hands and feet also fit into the system; the eyes and head turn towards a seen or heard object, and the hand reaches for it, all with great readiness and accuracy. Not all of this spatial integration needs to be learned, for, at least in animals that are born or hatched in a comparatively mature stage of development, movements made in response to visual stimuli are from the first well directed. On the other hand, in human beings at least, learning has much to do with the integration, as is shown by experiments in which one of the senses is thrown out of step with the others, causing immediate confusion with recovery through practice. Two striking experiments, similar in principle, will serve to illustrate learning and integration in spatial perception.

Stratton's experiment[13] on inverting the field of vision started from the fact that the picture thrown upon the retina

[13] G. M. Stratton, *Psychological Review*, 1896, vol. 3, pp. 611–617, and 1897, vol. 4, pp. 341–360, 463–481.

by the lens of the eye is upside-down — a fact that formerly caused much fruitless speculation as to how, then, we can see the field of view right side up. Stratton prepared a system of lenses that re-inverted the field of view, and wore this device constantly for a week, except at night when he was blindfolded. The lenses reversed right and left as well as up and down. The field of view was not distorted as a picture, and the eye and head movements of looking towards an object were not disturbed. But the relation of the visual field to hand, foot and body movements was reversed, with great resulting disturbance of movement and orientation. At first, everything looked upside down and reversed right and left, but in the course of the week, a new system of visual signs and spatial meanings was built up, and things looked right side up again. At first, movements in response to seen objects were entirely false, the subject reached in the wrong direction for any seen object, and ran into anything that he tried to avoid. Movements guided by the eye were laborious and nerve-racking, and had to be performed, either by patient calculation or else by mere trial and error. The subject's situation, in regard to movement, was the same as in the mirror-drawing experiment,[14] only more so; but as in mirror drawing the subject learns to guide his hands by the eye, so it was, more gradually, in this experiment with the completely reversed field of view. By the end of the week, the subject was able to walk freely about the house, and to perform all sorts of manual operations. Early in the experiment, after the subject had come to see what was before him right side up, he still could not think of what lay outside of his immediate field of view as belonging in the new system, and did not know in the least where to look for parts of the room that he did not actually see; but by the end of the week the new system extended to include objects not actually in sight, so that the subject's behavior in familiar sur-

[14] See above, page 141.

roundings became almost normal. When now he removed the lenses, at the end of the week, the first effect was one of pleased surprise at finding himself back in his old visual space; there was considerable bewilderment and movements were false again, since they continued to follow the new system. After a few hours, however, the old system was fully reëstablished. The old system had not been unlearned or damaged by the week's drill with the reversed fields. It is clear, from the experiment, that erect vision is just a matter of integrating visual data with other sense data and with bodily movement.

In Young's pseudophone ("false sound") experiment,[15] a somewhat similar disturbance was introduced in hearing. Recalling the fact that the ears, being stimulated differently by sound waves coming from the two sides, give a localization of the sound to the right or left, we may query what would be the effect of interchanging the two ears. Young fitted a tube into each ear hole, and carried it over the head to end in a horn or receiver on the other side. Thus each ear got the stimulus that would normally enter the other ear. The subject wore this instrument for an hour or two a day for two weeks, and then all day for three days. The results were like Stratton's but with a difference. The first effect was a complete right-left reversal in the localization of sounds, with much tendency to front-back reversal as well. The creaking of a door would be heard from the right rear and a person would be seen entering the door at the left front. Finding a ticking clock, with eyes closed, was a baffling task, for the more you went towards it the more it receded. With the eyes closed, this reversed localization persisted throughout the experiment with little indication that it would yield to training. But with eyes open the result was more in line with Stratton's. Even from the start of the experiment, when the object was *seen* making a

[15] P. T. Young, *Journal of Experimental Psychology*, 1928, vol. 11, pp. 399–429.

noise, as a horse walking in the street, the noise sometimes seemed to come from the seen object; the visual signs of location prevailed over the auditory. The visual cue at first had to be very clear in order to overbear the auditory, but as the experiment progressed, vision dominated more and more, and the visual localization remained even after an object had gone out of sight, so that the subject could be in a busy street and hear all the sounds as coming from their objectively true sources. When the instrument was finally removed, the switch back to normal localization was immediate and complete. Probably we may say that the experiment was not pushed so far as Stratton's; but at any rate it showed the learned integration of visual and auditory space cues.

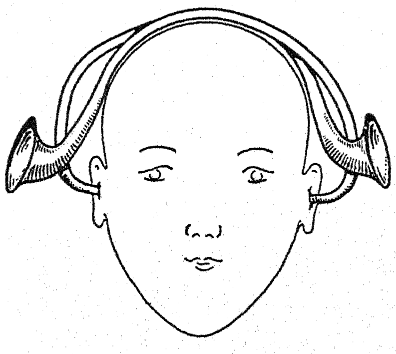


FIG. 52. — Diagram of Young's pseudophone. Each ear trumpet is continued by a tube that runs over the head and is plugged into the opposite ear.

PERCEIVING MOVEMENT AND CHANGE

When you think of it, movement and change are more commonly presented and perceived than a stationary condition of affairs. Even if the external objects are at rest, the organism itself is apt to move and change the stimulus received. We should probably think of change and movement as the normal state of affairs to be perceived. Several of the senses are well

adapted to stimulation by moving objects. We need only mention the muscle sense and the semicircular canals which are stimulated mostly by movement. Motion on the skin is readily sensed by touch, and the eye, especially outside the center of clear vision, is very sensitive to any movement of objects. The ear senses the motion in space of a sounding body, and it is specially sensitive to changes of pitch, which we often speak of as movements up or down the scale. Continuous change of this kind is given by the siren whistle, and also by the human voice in slides and inflections. Such change patterns are striking and easily perceived.

Motion pictures set an interesting problem in the perception of movement. What the audience sees is of course not the motion of the film itself as it snaps forward from one exposure to the next, for this motion is carefully concealed by the projecting apparatus, as otherwise it would be seen as a disturbing blur. The stimulus sent out to the audience consists of a series of still pictures, a series of instantaneous snapshots, no single one of which shows any motion. Whence comes the motion that you see in looking at this series of motionless views? Evidently the seen motion is your response, your response pattern. The film gives you a reduced cue for seeing a movement pattern, and has enough in common with an actually present moving object to arouse the same perception.

The lag of visual response, the positive after-image effect, has something to do with it, for without that the picture would be seen to be intermittent, as it is physically. But a more important factor is that the brain is tuned to see continuous motion, and grabs at any chance to see it. It sees motion much more readily than it can pick out the successive positions through which a moving body passes. Every one who has examined snap shots has been surprised at the queer positions into which a man, or a horse, gets in the course of his movements. We can scarcely believe that he actually takes

these positions. That means that we do not actually perceive the various intermediate positions that are passed through in a movement. We perceive the movement as a continuous pattern, but we do not perceive the consecutive positions.

Apparent movement can be seen with much simpler stimuli than those of the moving pictures. All you need is two lines, a short distance apart, presented one after the other to the eyes with a little blank interval between them. You can try the experiment by simply holding the forefinger upright three or four inches in front of the nose, and looking at it while winking first one eye and then the other. To the right eye it appears more to one side and to the left eye more to the other side; and when one eye is closed and the other simultaneously opened, the finger seems actually to move from one position to the other. This result is confirmed by careful laboratory experiments, which also show that the subject cannot tell the difference between a quick shift of position and an actual continuous movement across from one position to another. Turning and bending movements can also be seen when the successively shown lines are at an angle to each other or differently curved. If the time interval between the exposure of the two lines is very short, the lines are apt to be seen as present together, each in its own position; and if the interval is rather long, one line is seen in its position and then the other in its position, without apparent motion. But if the interval is just right, movement appears.

What may be the full explanation of the motion picture effect is not yet clear; but it is clear, first, that the organism is prone to see movement patterns, and, second, that in actual life movement is often what there is to see, so that this proneness of the organism is a good adaptation to objective reality.

ESTHETIC PERCEPTION

Beauty, humor, pathos and sublimity can be perceived by the senses, though we might debate a long time over the question whether these characteristics are really objective, or merely our own feelings aroused by the objects, and then projected into them. However that may be, there is no doubt that the ability to make these responses is something that can be trained, and that some people are blind and deaf to beauty and humor that other people clearly perceive. Many a one fails to see the point of a joke, or is unable to find any humor in the situation, which are clearly perceived by another. Many a one sees only a sign of rain in a great bank of clouds, only a weary climb in the looming mountain.

> " A primrose by the river's brim
> A yellow primrose was to him,
> And it was nothing more."

It would not be quite fair to describe such a one as lacking in feeling; he probably has, on sufficient stimulus, the same feelings as another man, and it would be more exact to say that he is lacking in perception of certain qualities and relations. He probably tends, by nature and training, to practical rather than esthetic perception. To see any beauty in a new style of music or painting, or to sense the humor in a new form of humorous writing, you need to be initiated, to be trained in observing the precise qualities and relations that are depended on for the esthetic effect. A complex situation presents almost an unlimited range of facts that may be perceived; no one perceives them all, and which he shall perceive depends on his nature and training, as well as on his attitude or mental set at the moment when the situation is presented.

Even the very simplest objects can produce an esthetic effect. You would scarcely suppose that a mere rectangle

could produce any esthetic effect, or that it would make any difference what exact proportions the rectangle possessed; and yet it is found that some rectangles are preferred to others, and that the popular choice falls upon what the art theorists have long known as the "golden section," a rectangle with a width about sixty-two per cent of its length. Also, however much you may like symmetry, you would scarcely suppose that it could make much difference where, on a horizontal line, a little cross line should be erected; and yet nearly every one, on being tested, will agree that the middle is the best point. These are merely a couple of sample results from the numerous studies in the field of psychological esthetics.

SOCIAL PERCEPTION

By the senses we perceive the motives and intentions of other people, their sincerity, goodness, intelligence, and many other traits. We see them angry or bored, amused, full of energy. To be sure, none of these human characteristics is directly and fully sensed, but that is the case also with many characteristics of inanimate objects which, nevertheless, we perceive by aid of the senses. We perceive anger or sincerity in much the same way that we perceive moisture or smoothness by the eye. To experience the anger of another person is a complex experience, but a single element from this experience may come to serve as the sign of the whole condition. A good share of the child's undirected education consists in learning to perceive the intentions and characteristics of other people by aid of little signs. He learns to read the signs of the weather in the family circle, and he learns in some measure to be a judge of men.

It would be very valuable if psychology could succeed in analyzing out the signs by which such a trait as intelligence or "will power" is perceived, so as to reduce such perception to a science. Some persons who themselves are keen observers

of such traits have put forward systems, based upon the shape of the face, etc. They probably think they perceive human traits according to their systems, but the systems fail in other hands, and are undoubtedly fallacious. No good judge of character really goes by the shape of the face; he goes by little behavior signs which he has not analyzed out, and therefore cannot explain to another person.

You can tell very little regarding a person's intelligence from his photograph. This has now been pretty well established. Photographs of persons of various degrees of intelligence are placed before those who are reputed to be good judges, and their estimates compared with the test ratings, and there is no close correspondence. You might almost as well look at the back of the photograph as at the front.

Even with the person before you, you are likely to commit great errors. This sort of incident has happened. A young woman is brought before the court for delinquency, and the psychologist who has tested her testifies that she is of low intelligence. But the young woman is good-looking and graceful in her speech and manners, and so impresses the judge that he dismisses as absurd the notion of her being feeble-minded. He sets her free, on which she promptly gets into trouble again. Apparently the only way to perceive intelligence is to see a person in action, preferably under standard conditions, where his performance can be measured; that is to say, in an intelligence test.

ERRORS OF PERCEPTION

The grocer needs to be assured of the accuracy of his scales, and the chemist of the high accuracy of his chemical balance. All who use instruments to assist in accurate perception of facts are concerned about the accuracy of their instruments. Now, we all use the senses in perceiving facts, and "errors of

sense" therefore concern us all. Some of the errors committed in sense perception can be laid at the door of the senses, and some belong in the sphere of perception proper.

If you come out of a cold room into a warm room, the latter seems warmer than it is; and if you come out of a dark room into a light room, the latter seems brighter than it is. These errors, due to adaptation of the temperature sense and of the retina, are properly classed as errors of sense.

If you are taking a child's temperature, it is best to use your watch to tell you when the minute is up, for a minute, if you are simply waiting for it to pass, seems very long. But if you are working against time, a minute seems short. The professor is shocked when the closing bell rings, and thinks that certainly the hour cannot be up; but some of the students have been consulting their watches for quite a long while. These are scarcely errors of sense, but they are errors of perception.

Where we tend to err in one certain direction from the truth, as in the examples just cited, psychology speaks of a *constant error,* and evidently the knowledge of such constant errors is of importance wherever the facts are of importance. In a court of law, a witness often has to testify regarding the length of time occupied by some event, and a knowledge of the constant errors in time perception would therefore be of legal importance. They would need to be worked out in detail, since they differ according to the desires and attitude of the witness at the time of the event.

Besides constant errors, there are accidental or variable errors, due to slight momentary causes. Both constant and variable errors can be illustrated by a series of shots at a target. The *variable error* is illustrated by the scatter of the hits, and the constant error by the excess of hits above the bull's-eye, or below, or to the right or left. The constant error can be corrected, once you know what it is; if results show that

you tend to shoot too high, you can deliberately aim lower. But the variability of any performance cannot be eliminated except by long practice, and not altogether even then.

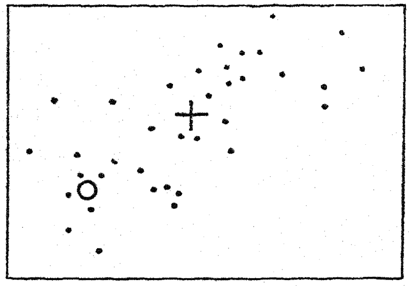


Fig. 53. — Constant error and scatter in hitting at a target. The little circle was the target, but the center of the actual distribution of the attempts lies at the cross, which was drawn in afterwards. The constant error could be stated by saying that the center of distribution was so far from the target, and in such and such a direction. The scattering of the attempts can be measured also.

Experimental psychology has taken great pains in measuring the accuracy of different sorts of perception. How small a difference in length can be perceived by the eye, how small a difference of weight by the hand — these are sample problems in this line.

For example, to measure the fineness with which weights can be perceived when "hefted" in the hand, you take two objects alike in size and appearance but differing slightly in weight, and endeavor to decide which is the heavier just by lifting them. You try repeatedly and keep track of the number of errors. If one weight were twice as heavy as the other (one, for example, weighing 100 grams and the other 200), you would never make an error except through carelessness; but if one were 100 and the other 120 grams, you would make an occasional error, and the number of errors would increase as the difference was decreased; finally, comparing 100 and 101 grams, you would get almost as many wrong as right, so that

your perception of that small difference would be extremely unreliable.

ERRORS IN PERCEIVING SMALL DIFFERENCES OF WEIGHT
(From Warner Brown, 1910)

Difference	20	16	12	8	4	3	2	1	grams
Errors	1	2	5	13	28	31	39	44	per hundred trials

The weights were in the neighborhood of 100 grams; each weight was compared with the 100-gram weight, and each such pair was lifted and judged 1400 times. Notice that the per cent of errors gradually increases as the difference becomes smaller.

The smaller the difference between two stimuli, the more numerous the errors in perceiving it, or, the less perceptible it is, and there is no sharp line between a difference that can be perceived and one that is too small to be perceived. That is the first great result from the study of the perception of small differences.

The second great result is called *Weber's law,* which can be stated as follows: In the same sort of perception, equal relative (not absolute) differences are equally perceptible. For example, from the preceding table we see that 28 per cent of errors are made in comparing weights of 100 and 104 grams; then, according to Weber's law, 28 per cent of errors would also be made in comparing 200 grams with 208, or 500 with 520, or 1000 with 1040 grams, or any pair of weights that stood to each other in the ratio of 100 to 104. Weber's law is only approximately true for the perception of weights, since actually fewer errors are committed in comparing 500 and 520 than in comparing 100 and 104 grams; but the discrepancy is not extremely great here, and in some other kinds of perception, as especially in comparing the brightness of lights or the length of seen lines, the law holds good over a wide range of stimuli and only breaks down near the upper and lower extremes. We are familiar, in ordinary life, with the general truth of Weber's law, since we know that an inch would make

a much more perceptible addition to the length of a man's nose than to his height, and we know that turning on a second light when only one is already lit gives a much more noticeable increase in the light than if we add one more light when twenty are already burning. The larger the *relative* change, the more perceptible.

A third great result of this line of study is that different sorts of perception are very unequal in their fineness and reliability. Perception of brightness is about the keenest, as under favorable conditions a difference of one part in one hundred can here be perceived with very few errors. Visual perception of length of line is good for about one part in fifty, perception of lifted weight for about one part in ten, perception of loudness of sound for about one part in three.

ILLUSIONS

An error of perception is often called an "illusion" though this term is commonly reserved for errors that are large and curious. An illusion consists in responding to a sensory stimulus by perceiving something that is not really there. The stimulus is there, but not the fact which it is taken to indicate. Illusion is false perception.

The study of illusions is of value, not only as showing how far a given kind of perception can be trusted, but also as throwing light on the process of perception. When a process goes wrong, it sometimes reveals its inner mechanism more clearly than when everything is running smoothly. Errors of any kind are meat to the psychologist.

Illusions may be classified under several headings according to the factors that are operative in causing the deception.

1. **Illusions due to peculiarities of the sense organs.** Here the stimulus is distorted by the sense organ and so may easily be taken as the sign of an unreal fact.

Separate the points of a pair of compasses by about three-

quarters of an inch, and draw them across the mouth, one point above it and the other below; you will get the illusion of the points separating as they approach the middle of the mouth (where the sensory nerve supply is greatest), and coming together again as they are drawn to the cheek at the other side.

Under this same general head belong also after-images and contrast colors, and also double vision whenever for any reason the two eyes are not accurately converged upon an object. The fact that a vertical line appears longer than an equal horizontal is supposed to depend upon some peculiarity of the retina. Aside from the use of this class of illusions in the detailed study of the different senses, the chief thing to learn from them is that they so seldom are full-fledged illusions, because they are ignored or allowed for, and not taken as the signs of facts. An after-image would constitute a genuine illusion if it were taken for some real thing out there; but as a matter of fact, though after-images occur very frequently — slight ones practically every time the eyes are turned — they are ignored to such an extent that the student of psychology, when he reads about them, often thinks them to be something unusual and lying outside of his own experience. The same is true of double vision. This all goes to show how strong is the tendency to disregard mere sensation in the interest of getting objective facts.

2. **Illusions due to preparatory set.** When an insane person hears the creaking of a rocking-chair as the voice of some one calling him bad names, it is because he is preoccupied with suspicion. We might almost call this an hallucination,[16] since he is projecting his own auditory images and taking them for real sensations; it is, at any rate, an extreme instance of illusion. In a milder form, similar illusions are aften momentarily present in a perfectly normal person, as when he is searching

[16] See page 115.

for a lost object and thinks he sees it whenever anything remotely similar to the desired object meets his eyes; or as when the mother, with the baby upstairs very much on her mind, imagines she hears him crying when the cat yowls or the next-door neighbors start their phonograph. The ghost-seeing and burglar-hearing illusions belong here as well. The set facilitates responses that are congruous with itself.

3. **Illusions of the false cue type.** This is the commonest source of everyday illusions, and the same principle, reduced

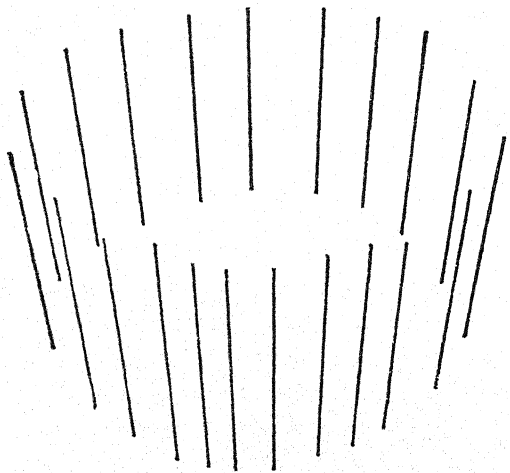


FIG. 54. — The Ladd-Franklin illusion of monocular perspective. Close one eye, and hold the book so that the other eye is at the common center from which the lines radiate; this center is about 5 inches from the figure. Hold the book horizontally, and just a little below the eye.

cues, is operative in a host of correct perceptions. Perceiving the obliquely presented rectangle as a rectangle is an example of correct perception of this type. Perceiving the buzzing of a fly as an aeroplane is the same sort of response only that it happens to be incorrect. If the present stimulus has something in common with the stimulus which has in the past aroused a certain perception, we may make the same response now as we

did before — espcially, of course, if the preparatory set favors this response.

A good instance of this type is called the "proofreader's illusion," though the professional proofreader is less subjcet to it than any one else. It is almost impossible to find every misspelled word and other typographical error in reading proof.

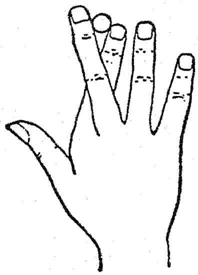


FIG. 55. — Aristotle's illusion.

Almost every book comes out with a few such errors, in spite of having been scanned repeatedly by several people. A couple of misprints have purposely been left in the last few lines for the reader's benefit. If the word as printed has enough

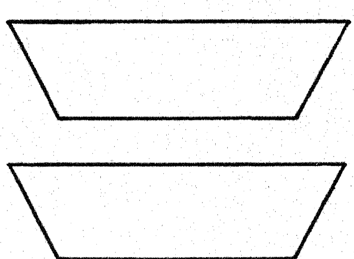


FIG. 56. — The pan illusion. The two pan-shaped outlines are practically identical, but it is hard to compare the corresponding sides — hard to isolate from the total figure just the elements that you need to compare.

resemblance to the right word, it arouses the same response and enables the reader to get the sense and pass on satisfied.

Another illusion of this general type dates away back to Aristotle. Cross two fingers, and touch a marble with the crossed part of both fingers, and it seems to be two marbles; or, you can use the side of your pencil as the stimulus. In the customary position of the fingers, the stimuli thus received would mean two objects.

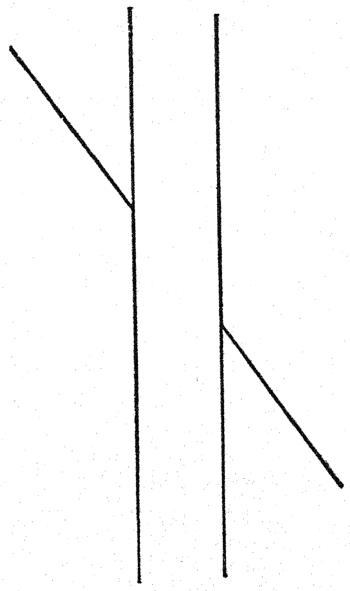


FIG. 57. — The Poggendorf illusion. Are the two obliques parts of the same straight line?

4. **Illusions due to imperfect isolation of the fact to be perceived.** Here belong most of the illusions produced in the psychological laboratory by odd combinations of lines, etc. A figure is so drawn as to make it difficult to isolate the fact to be observed, and when the observer attempts to perceive it, he falls into error. He thinks he is perceiving one fact, when he is perceiving another. The best example is the Müller-Lyer figure, in which two equal lines are embellished with extra lines

at their ends; you are supposed to perceive the lengths of the two main lines, but you are very apt to take the whole figure in the rough and perceive the distances between its chief parts. You do not succeed in isolating the precise fact you wish to observe. (See page 418.)

Though these illusions seem like curiosities, and far from everyday experience, they really do enter in some degree into almost every figure that is not perfectly square and simple. Any oblique line, any complication of any sort, is pretty sure to alter the apparent proportions and directions of the figure. A broad effect, a long effect, a skewed effect, may easily be produced by lines introduced into a dress, into the front of a building, or into a design of any sort; so that the designer needs to have a practical knowledge of this type of illusion.

Extra lines have an influence also upon esthetic perception. The esthetic effect of a given form may be quite altered by the introduction of apparently insignificant extra lines. Esthetic

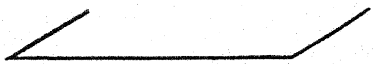


FIG. 58. — By aid of this simple figure, the Poggendorf illusion can be seen to be an instance of the Müller-Lyer illusion. Try to bisect the horizontal line in this figure. The oblique line at the right tends to displace the right-hand end of the horizontal to the right, while the oblique at the left tends to displace the left-hand end of the horizontal also to the right.

perception is very much subject to the law of combination, and to the resulting difficulty of isolation.

One of the most interesting illusions, not being visual, can only be described and not demonstrated here. It is called the "size-weight illusion," and may be said to be based on the old catch, "Which is heavier, a pound of lead or a pound of feathers?" Of course, we shrewdly answer, a pound's a pound. But lift them and notice how they feel! The pound of lead feels very much heavier. To reduce this illusion to a labora-

The Müller-Lyer Illusion

The most familiar form of this striking illusion is made with arrow heads, thus

In attempting to compare the two horizontal lines one is confused so as to regard the line with outward-extending obliques longer than that with inward-extending obliques, though, measured from point to point, they are equal. The same illusion occurs in a variety of similar figures, such as > < > where the main lines are not drawn, but the distances from point to point are to be compared; or such as ▶ ◀ ▶ where the two distances between points are again to be compared. Angles, however, are not necessary to give the illusion, as can be seen in this figure ⊃ C ⊃, or in this O O O.

In the last the lengths to be compared extend (*a*) from the right-hand rim of circle 1 to the left-hand rim of circle 2, and (*b*) from this last to the right-hand rim of circle 3. The same illusion can be got with squares, or even with capital letters as E Ǝ E or R Я R, where the distances between the main vertical lines are to be compared.

Here is an another form of the same illusion

the middle lines being affected by those above and below.

tory experiment, you take two round wooden pill-boxes, one several times as large as the other, and load them so that they both weigh the same; then ask some one to lift them and tell which is the heavier. He will have no doubt at all that the smaller box is the heavier; it may seem two or three times as

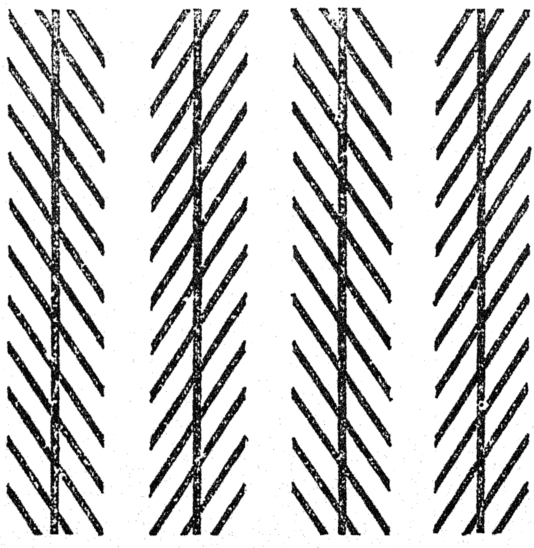


FIG. 59. — The Zoellner illusion. The long lines are really parallel. The illusion is increased by holding the figure so that these main lines shall be neither vertical nor horizontal. It is more difficult to deceive the eye in regard to the direction of vertical and horizontal lines, than in regard to the direction of oblique lines. This illusion must be related in some way to the Müller-Lyer and Poggendorf illusions, since the elements employed in constructing the three figures are so much the same.

If you treat this figure according to the directions given for Fig. 54, and sight along the obliques, you get an illusion of perspective.

heavy. Young children, however, get the opposite illusion, assimilating the weight to the visual appearance; but older persons switch over to the contrast effect, and perceive in opposition to the visual appearance. What seems to happen in the older person is a motor adjustment for the apparent weights, as indicated by their visual appearance, with the result that

the weight of larger size is lifted more strongly than the weight of smaller size; so that the big one comes up easily and seems light, the little one slowly and seems heavy.

THE NATURE OF PERCEPTION

We started by saying that observation included a preparatory step, called attention, and a main step which we called perception and which we defined as the knowing of facts presented to the senses. We admitted that this definition simply stated the result of the process and did not describe the process itself. We have since found out a number of things concerning the process. We found that it was both selective and combining, that it always isolated a figure from the total background, but that the figure was typically a pattern or group, and that it took special motivation to narrow the figure down to a point. Then we found that perceived figures were usually taken as objective things or other facts, or as signs of objective facts, and that the connection of sign and meaning was due to learning. We should add that perception is itself a preliminary to motor reaction. When an individual comes into a new situation, he observes one fact after another, so building up a knowledge of the situation as it is, and this is preliminary to his taking a hand in the situation, to his making some motor response to it and so changing it.

Perception, then, is sandwiched in between sensation on one side and motor response on the other. It utilizes sensations, by selecting and combining them, and by finding in them signs of objective facts, and thus it makes it possible for motor activity to take account of the existing objective situation.

In the interests of simplifying psychology, some theories try to merge perception with sensation, and others to merge it with the motor response; but these simplifications simply will not work or do justice to the subject.

Perception and sensation. Shifting perception, such as we found in observing dot figures and figures in ambiguous perspective, shows something changing while sensation remains constant. The grouping process, then, is not identical with the process of receiving a mass of sensory stimuli. When an unusual fact is presented we may not know the fact at once, though the sensation is there. We may be baffled for an instant, and have sensation without knowing the objective fact, or we may shift from one suggested meaning to another. In one instance, a noise was first heard as distant thunder, and then, correctly, as somebody walking on the floor above. On touching something in the dark, you may feel it as one thing and another till some perception is aroused that fits the known situation and satisfies you. Such shifts of perception, while sensation remains virtually unchanged, can be frequently observed if one is on the watch.

Perception and movement. At first thought, it is absolutely wild to try to merge perception and movement, knowing and doing. Is not the typical bodily attitude during careful perception one of immobility? And is not such momentary inhibition of movement just what is demanded by the needs of the organism? The organism needs to act in accordance with the facts, and the facts must first be observed; therefore it is to be expected that perception, while preliminary to movement, should itself be non-motor.

On second thought, doubts begin to obtrude themselves. We remember how closely bound together in the child's activity are his observation of objects and his manipulation of them. True enough, the child does spend a good deal of time simply watching what is going on, without participating, but the intimate combination of seeing and doing seems more typical of naïve behavior. Let us remember also how reading, which in the practiced adult appears as a purely perceptive, non-motor activity, begins in the child with reading aloud, and progresses

through a whispering stage and a lip-moving stage to the non-motor stage — which suggests that perception may be fundamentally a motor response, only that, with practice, the movement is reduced to a minimum and perhaps becomes so slight as to be invisible.

On theoretical grounds, some psychologists prefer to believe that every activity issues in immediate movement, however slight, and therefore they hold that perceiving any object involves some little motor adjustment to the object. Seeing a door knob involves, they say, an incipient movement of turning it, perceiving your friend in the distance consists in incipient friendly movements, and perceiving your enemy in incipient wary movements. This sounds reasonable in these cases, but less so when applied to seeing the moon or hearing a rooster crow. It is hard to imagine what characteristic motor response can be made to the thousand and one things and happenings that we perceive. However, the motor theory of perception is a respectable theory, only that it can only be regarded as a theory.

What is more important than the possible motor element in all perception is the inhibition of overt movement that characterizes it. An intelligent individual, confronted with a situation demanding action on his part, looks the situation over, noting this fact and that and so building up a knowledge of the whole situation. He does not go off at half cock by impulsive motor response to this or that particular fact, but abstains from action till he has the situation in hand. If he does make incipient movements in response to each fact as he observes it, the important point is that he keeps them incipient. In trying to describe intelligent behavior,[17] we mentioned *breadth* as one of its characteristics. Now we have reached the point in our analysis of behavior where the breadth comes in. Breadth means delaying response to one ob-

[17] See page 61.

served fact while surveying the situation for other pertinent facts.

The simplest organisms, though responsive to light, respond merely to the total mass of light by approaching or avoiding movements. With the development of eyes that give detailed pictures, and of brains that can be thrown into elaborate patterns of activity, mere mass seeing gives way to seeing figures. With learning or "conditioning," these visible figures become signs of real objects, and so the organism is adjusted not only to the quantity of light present, but to the presence of definite objects. With increasing breadth, or power of motor inhibition, adjustment becomes possible to complex situations including many perceived objects. Meanwhile, we should not neglect to remind ourselves, manipulation does, in large measure, go hand in hand with observation, and greatly assists in the process of becoming acquainted with objects.

EXERCISES

1. Compare the way the general laws of reaction work out in attention and in reflex action.

2. Compare the stages in the development of attention with the stages in practice mentioned under the head of effort in Chapter VI.

3. Can you explain away the apparent inconsistency, between doing or perceiving two things at once, and the law of selection?

4. Compare the process of developing a habit of inattention with the process of extinguishing a conditioned reflex.

5. How does the shifting that appears in ambiguous figures differ from the simple shifting of attention?

6. Make a study of your own habits of study, and ask whether you could defend all of them on the ground of efficiency.

7. Try your hand with some figures to bring out the factors of advantage in the seeing of groups.

8. Give a number of illustrations to show how perception is influenced by familiarity.

9. Explain how it comes that when you are waiting for a friend, you often believe you see him coming only to find later that it was somebody else.

10. Binocular parallax, or the differing views of the same solid object obtained by the two eyes. Hold a small, three-dimensional object a foot in front of the face, and notice carefully the view of it obtained by each eye separately. Roll a small cone of paper, hold it with the point towards you, and make a line drawing of its appearance to each eye. If these two views were properly combined stereoscopically, what impression would one get from them?

11. Trial and error perception. With eyes closed, explore a lot of miscellaneous objects with the hands. Some of the objects will doubtless be recognized instantly, but others not so easily. In perceiving the latter, describe anything resembling trial and error, or anything resembling a shifting of meanings.

12. To which of the facts mentioned under the head of "errors of perception" is each of the following analogous?

(a) Bias of judgment, making you rank your friends higher than they deserve, in comparison with strangers.

(b) The bigness of a dollar, when you have only five, and its comparative insignificance when you have a hundred.

13. What, after all that has been brought forward, seems to be the essential process of perception?

REFERENCES

Attention is given full treatment by W. B. Pillsbury, *Attention*, 1908; and by E. B. Titchener, *Textbook of Psychology*, 1909, pp. 265–302.

Many interesting facts on perception can be found in E. S. Robinson and F. R. Robinson, *Readings in General Psychology*, 1923, pp. 226–288; and in G. M. Whipple, *Manual of Mental and Physical Tests*, 1914, vol. 1, pp. 164–349.

CHAPTER X

THINKING

HOW DISCOVERIES ARE MADE BY COMBINING PREVIOUSLY OBSERVED FACTS

Though knowledge rests upon the observation of facts, every one recognizes that thinking as well has much to do with it. Thinking previous to observation makes the observation pointed and worth while; and thinking subsequent to observation systematizes the observed facts into coherent and useful bodies of knowledge. The exploration of a strange region, for example, will be better done if carefully planned in advance; and, after the explorers have brought their data home and have combined them into maps and systematic descriptions, they may discover relationships that they did not observe out in the field.

The ability to think, plan, systematize and reason is so characteristically human and of so high an order that we are tempted to assume a rational activity in man that is altogether new, and different from anything we have found in learning, memory, sense perception or motor activity. But, so far as the thinking processes have been studied — they are not easily subjected to exact observation and experimentation — no radically new type of activity has been revealed. Apparently there is no new type of activity involved in thinking, but rather a combination of elementary forms of activity which we have already met, especially of:

1. recall of previously observed facts;
2. grouping and patterning of facts;
3. trial and error in handling of the facts;
4. motivation, or control by the task or activity in progress.

What characterizes thinking is the combination of these elementary activities, and, we may add, their freedom and mobility in the combined activity. Freedom may be illustrated by "free ideas," which, though dependent on memory, are not tied up with any single past experience, nor are they tied to objects now presented, nor to motor acts now being executed. Some of these ideas refer to individual persons or things, as your idea of your home, and some, at the other extreme, are very abstract, as your idea of competition or of progress. But since they are not bound to particular memories or to particular present objects or to particular present acts, you can play with them, manipulate them, and use them freely. You can put any two ideas together, and see how the combination strikes you, or what it suggests. By bringing together facts observed at different times and places, you make them fall into groups and patterns that you never saw before and perhaps nobody ever saw before, and looking over this imaginary set-up may lead you to a discovery or an invention. Thinking is putting two and two together.

While the ideas present in thinking are free ideas in the sense just defined, they are subject to control by desires and interests, just as muscular activities are. Sometimes they are so controlled and sometimes not. Before taking up reasoning and mental work, in which there is a goal or task that exerts control, we may consider the simpler types of thinking that go under the name of free association.

FREE ASSOCIATION

Mental processes that make use of previously observed facts, and so depend on the recall of those facts, are often called " associative activities," since they make use of associations or linkages formed in previous learning. When some definite interest or purpose steers the associative processes, we speak of " controlled association," contrasting this with the " free association " that occurs in an idle mood, when one thought simply calls up another with no object in view and no more than fleeting desires to give direction to the sequence of thoughts.

Revery affords the best example of free association. I see my neighbor's dog out of my window, and am reminded of one time when I took charge of that dog while my neighbor was away, and then of my neighbor's coming back and taking the dog from the cellar where I had shut him up; next of my neighbor's advice with respect to an automobile collision in which I was concerned; next of the stranger with whom I had collided, and of the stranger's business address on the card which he gave me; next comes a query as to this stranger's line of business and whether he was well-to-do; and from there my thoughts switch naturally to the high cost of living.

This is rather a drab, middle-aged type of revelry, and youth might show more life and color; but the linkages between one thought and the next are typical of any revery. I had previously observed the ownership of this dog by my neighbor, and this observation linked the dog and the neighbor and enabled the dog to recall the neighbor to my mind. One fact recalls another when the two have been previously observed as belonging together.

But suppose, as is commonly the case, that the fact now present in my mind has been linked, in different past experiences, with several different facts. Then two questions de-

mand our attention: whether all these facts are recalled; and, if not, what gives the advantage to the fact actually recalled over the others that are not recalled.

The answer to the first question is plain. The fact first present in mind does not call up all the associated facts, but usually only one of them, or at least only one at a time. My neighbor, in the example given, though previously associated with a dozen other facts, now calls up but two of these facts, and those two not simultaneously but one after the other. This is the way our familiar *law of selection*[1] works out in the associative processes. If a given fact, now present as a cue, has been linked in the past with several different facts, it recalls just one of them at a time, though it may call up several in succession, provided we dwell on the fact that is the cue. Dwelling on the thought of a certain person may call up in succession many facts connected with him. In revery, however, one usually does not "dwell," but moves by a series of links very far from the thought that started the whole chain.

If, then, only one of the several facts associated with the stimulus is recalled at once, our second question presents itself, as to what are the *factors of advantage* that cause one rather than another of the possible responses to occur. The fact first in mind might have called up any one of several facts, having been linked with each of them in past experience; and we want to know why it recalls one of these facts rather than the rest.

The factors of advantage in recall are the factors that determine the strength of linkage between two facts; and they are:

> the *frequency* with which the linkage has occurred;
> the *recency* with which it has occurred; and
> the *intensity* with which it has occurred.

[1] See pages 233, 376.

If I have frequently observed the connection of two facts, the linkage between them is strong; if I have recently observed their connection, the linkage between them is strong till the "recency value" dies away; and if my observation of the connection of the two facts was a vivid experience, or intense reaction, then, also, the linkage between them is strong. If these three factors of advantage work together in favor of the same response, then that response is sure to occur; but if the three factors pull different ways, we should have to figure out the balance of advantage before we could predict which of the possible responses would actually be made. Strong recency value offsets a lot of frequency; so that a mere vague allusion to a very recent topic of conversation can be depended on to recall the right facts to the hearer's mind. "James," by virtue of frequency, means your brother or friend; but when the lecturer is talking about the psychologist James, repetition of this name infallibly recalls the psychologist to mind.

Besides frequency, recency and intensity, there is, indeed, another factor to be taken into account; and that is the present state of the individual. If he is unhappy, unpleasant associations have the advantage; if happy, pleasant. If he is absorbed in a given matter, facts related to that matter have the advantage. Frequency, recency and intensity summarize the *history* of associations, and measure their strength as dependent on their history; but the present state of mind is an additional directive factor, and when it has much to do with recall, we speak of directed or controlled association.

The free association test. Before we pass to the topic of controlled association, however, there is another form of free association, quite different from revery, to be examined. There is an experiment in which the subject is given a series of words as stimuli, and is asked to respond to each word by speaking some other word, the first that is recalled by the

stimulus. No special kind of word need be given in response, but simply the *first word recalled.* Though this is called free association, it is controlled to the extent that the response must be a word, and the result is very different from revery. Instead of the recall of concrete facts from past experience, there is recall of words. If you give the subject the stimulus word, "table," his response is "chair" or "dinner," etc., and often he does not think of any particular table, but simply of the word. Words are so often linked one with another that it is no wonder that one recalls another automatically. What particular word shall be recalled depends on the frequency, recency and intensity of past linkage.

Though this form of test seems so simple as almost to be silly, it is of use in several ways. When a large number of stimulus words are used, and the responses classified, some persons are found to favor linkages that have a personal significance — "egocentric responses," these are called — while other persons run to connections that are impersonal and objective. Thus the test throws some light on the individual's habits of thought.

The test has also a "detective" use, based upon the great efficacy of the factor of *recency;* you may be able by it to tell whether an individual has recently had a certain matter in mind. If he happens to be an individual who has recently committed some crime, properly selected stimulus words will lead him to recall the scene of the crime, and thus to make responses that betray him, unless he checks them and so arouses suspicion by his hesitation. This device has been used successfully in some cases, but has not been adopted as regular police procedure.

Another use of the test is for unearthing a person's emotional "complexes," which of course possess a high *intensity* value. If the subject shows hesitation and embarrassment in responding to words referring to money, the indication is that

he is emotionally disturbed over the state of his finances. One person who consulted a doctor for nervousness made peculiar responses to stimulus words relating to the family, and was discovered to be much disturbed over his family's opposition to his projected marriage. The free association test is useful rather as giving the experienced psychologist hints to be followed up than as furnishing sure proof of the contents of the subject's mind.

CONTROLLED ASSOCIATION

There is a controlled association test conducted like this one in free association, except that the subject is required to respond to each stimulus word by a word standing in a specified relation to it. To one series of words he must respond by saying their opposites; to another, by mentioning a part of each object named; and there are many tests of this sort, each dealing with some class of relationships. The intelligent subject makes few errors in such a test, and responds in very quick time. Indeed, the remarkable fact is that he takes less time to respond in an easy controlled association test than in the free association test; which shows that the "control" acts not simply to limit the response, but also to *facilitate* it.

Set or preparation in controlled association. Controlled association belongs under the head of "prepared action,"[2] and the control is exerted by a preparatory set. On being told you are to give opposites, you set or adjust yourself for this type of response. Your set facilitates responses of the required type, while inhibiting other responses that would readily occur in the absence of any control. If the word "good" came as a stimulus word in a free association test, it might easily arouse the responses, "good day," "good night,"

[2] See page 235.

"good boy," "good better," and many besides, since all of these combinations have been frequently used in the past; and the balance of frequency, recency and intensity might favor any one of these responses. But when the subject is set for opposites, these factors have little force as against the set. The set for opposites favors the revival of such combinations as "new — old," "good — bad," and such others of this class as have been noted and used in the subject's past experience.

The preparatory set is thus a powerful factor of advantage. Without superseding the previously formed associations, it selects from among them the one which fits the present task. Does it get in its work after recall has done its part, or before? Does it wait till recall has brought up a number of responses, and then pick out the one that fills the bill? No, it often works much too quickly for that, giving the right response instantly; and introspection is often perfectly clear that none but the right response is recalled at all. The selective influence of the mental set is exerted *before recall;* it facilitates the right recall and inhibits recall of any but the right response. The process is much more efficient than it would be if the stimulus word called up a lot of free associations, from which the right response was then selected.

The preparatory set is itself a response to the preliminary stimulus of being told you are to give opposites, etc. It is an activity that goes as far as it can, but must of necessity remain incomplete until the word is supplied to which the opposite is to be given. A subject who is new to this experiment can easily observe in himself something of this preparatory activity. The activity may take the form of mentally running over examples of opposites — or whatever kind of responses are to be called for — or it may take the form of calling up some image or diagram or gesture that symbolizes the task. A visual image of the nose on the face may serve as a symbol of the part-whole relationship, a small circle inside a larger

one may symbolize the relation of an object to a class of objects, and gesturing first to the right and then to the left may symbolize the relationship of opposites. But as the subject grows accustomed to a given task, these conscious symbols fade away, and nothing remains except a general feeling of readiness and assurance; but the set remains in force and is no less efficient for becoming almost unconscious.

Mental work of the controlled association type. Controlled association enters into all forms of mental work — into arithmetical work, for example. A pair of numbers, such as 8 and 3, has been linked in past experience with several responses; it means 83, it means 11, it means 5, and it means 24. But if you are adding, it means 11, and no other response occurs; if you are multiplying, it means 24, and only that response occurs. The set for multiplying facilitates the responses of the multiplication table and inhibits those of the addition table, while the set for adding does the reverse. Rapid adding or multiplying would be impossible without an efficient set. Thus in arithmetic the set is a response to the *task.*

In reading, the set is a response to the *context,* and determines which meaning of a word shall actually be called to mind when the word is read. Presented alone, a word may call up any of its meanings, but in context it brings to mind just the one meaning that fits. The same is true in conversation.

The objective *situation* arouses a set that controls both thought and action. The set of being in church, for example, determines the meanings that are got from the words heard, and controls the motor behavior to fit the occasion. The subject, observing the situation, adjusts himself to it, and his adjustment facilitates appropriate reactions, while inhibiting others.

A *problem* arouses a set directed towards solution. A difficult problem, however, differs from a familiar task in this important respect, that the appropriate response has not been

previously linked with the present stimulus, so that, in spite of ever so good a set, the right response cannot immediately be aroused. One must *search* for the response, but the set is useful in directing the search. Problem solution is so different a process from smooth-running controlled association that it deserves separate treatment, which will be given it under the caption of reasoning.

REASONING

Reasoning may be described as mental exploration. Suppose you need the hammer, and go to the place where it is kept, only to find it gone. Now if you simply proceed to look here and there, ransacking the house without any plan, that would be motor exploration. But if, finding this trial and error procedure to be hopeless, you sit down and think, "Where can that hammer be? Probably where I used it last!" you may recall using it in a certain place, go there and find it. You have substituted mental for motor exploration, and saved time and effort. Such instances show the use of reasoning, and the part it plays in behavior.

The *process* of reasoning is also illustrated very well in these simple cases. In a way, it is a trial and error process. If you don't ransack the house, at least you ransack your memory. You recall this fact and that, you turn this way and that, mentally, till some fact is recalled that serves your need. No more in reasoning than in motor exploration can you hope to go straight to the desired goal.

The reader familiar with geometry, which is distinctly a reasoning science, can readily verify this description. It is true that each demonstration is set down in the book in an orderly manner, proceeding straight from the given assumption to the final conclusion; but such a demonstration is only a dried specimen and does not by any means picture the living mental process of reasoning out a proposition. Solving an

"original" is far from a straightforward process. You begin with a situation (what is "given") involving a problem (what is to be proved), and studying over this layout you see a clue; this recalls some previous proposition, but often turns out to have no bearing on the problem, so that you shift to another clue; and so on, by what is certainly a trial and error process, till some fact noted in the situation plus some knowledge recalled by this fact, taken together, reveal the truth of the proposition.

Reasoning, following up one clue after another, certainly has the form of trial and error. It differs from mere trial and error in that it follows up its clues by thinking them through, instead of by motor exploration. It follows them up by recall of previously observed facts. Often, to be sure, reasoning cannot reach a solution, cannot think its clues through to the bitter end, but has to give way to actual exploration and the observation of fresh facts.

Reasoning culminates in inference. When you have described reasoning as a process of mental exploration, you have told only half the story. The successful reasoner not only seeks, but finds. He not only ransacks his memory for data bearing on his problem, but, when memory has supplied the data, he sees their bearing on the problem. What the exploratory process does for him is to assemble data from different sources, and his job then is to see what the data mean, when taken together. He must grasp the interrelations of the data, he must get the pattern of the grouped data. The response he has to make to the data is the same sort of response that he makes in perceiving a pattern or object presented to the senses. The reasoner has to perceive a pattern that is *not* presented at the moment to his senses. Part of his data may be actually present but part at least is supplied by recall and he must grasp the pattern and meaning of the whole, the mutual relationship and bearing of the assembled data. He sees that

something *must be so.* This type of seeing or grasping is called *inference.*

To bring out distinctly the seeing or grasping that occurs in reasoning, let us examine a few simple cases. Two freshmen in college, getting acquainted, ask about each other's fathers and find that both are alumni of this same college. "What class was your father in?" "In the class of 1900. And yours?" "Why, he was in 1900, too. Our fathers were in the same class; they must know each other!" Here two facts, one contributed by one person and the other by another person, enable them to see or infer a third fact which neither of them knew before. Inference, typically, is a response to two facts, and the response consists in seeing a third fact that is bound up in the other two.

You do not need to infer what you can perceive directly by the senses. If Mary and Jane are standing side by side, you can see directly which is taller. But if they are living far apart, you can still tell which is the taller, provided each one is measured with a good yardstick and the two facts compared.

"Have we set the table for the right number of people?" "Well, we can see when the party comes to the table." "Oh! but we can tell now by counting. How many are there to be seated? One, two, three — fifteen in all. Now count the places at table — only fourteen. You will have to make room for one more." This reducing of the problem to numbers and then seeing how the numbers compare is one very simple and useful kind of inference.

Indirect comparison may be accomplished by other similar devices. I can reach around this tree trunk, but not around that, and thus I perceive that the second tree is thicker than the first, even though it may not look so. If two things are each found to be equal to a third thing, then I see they must be equal to each other; if one is larger than my yardstick and the other smaller, then I see they must be unequal.

Of the two facts which, taken together, yield an inferred fact, one is often a general rule or principle, and the inference then consists in seeing *how the general rule applies* to a special case. A dealer offers you a fine-looking diamond ring for five dollars, but you recall the rule that "all genuine diamonds are expensive," and perceive that this diamond must be an imitation.

Often inference consists in combining two relationships, and seeing a third relationship which is bound up in the other two. If Mary is taller than Jane, when they stand up together, and if by similar direct evidence Jane is taller than Winifred, then, putting these two relationships together, you infer that Mary is taller than Winifred. In general, when you have in mind a relation between A and M, and also a relation between B and M, you may see some resulting relation between A and B. M is the common point of reference to which A and B are related.

Difficulties in reasoning. Just as an illusion is a false sense perception, so a false inference is called a "fallacy." One great cause of fallacies consists in the confused way in which facts are sometimes presented, resulting in failure to see the relationships clearly. If you read that

> "Smith is taller than Brown; and
> Jones is shorter than Smith; and therefore
> Jones is shorter than Brown,"

the mix-up of "taller" and "shorter" makes it difficult to get the relationships clearly before you, and you are likely to make a mistake. Or again, if Mary and Jane both resemble Winifred can you infer that they resemble each other? You are likely to think so at first till you notice that resemblance is not a precise enough relation to serve for purposes of indirect comparison. Mary may resemble Winifred in one respect, and

Jane may resemble her in another respect, and there may be no resemblance between Mary and Jane.

The difficulty in seeing the point, and drawing a correct inference from the data, depends not wholly on the pattern of relationships that has to be seen, but also on the concreteness of the data in which the relationships are presented. Compare the difficulty of the following two problems in logical reasoning:

1. Some of the boats on the river are sail-boats;
   Robert's boats are on the river;
   Therefore, some of Robert's boats are sail-boats.
2. Some x's are y's;
   All z's are x's;
   Therefore, some z's are y's.

The logical relations are identical in the two cases; and yet only 2.5 per cent. of college students made a mistake on the first set, while 73 per cent. erred on the second.[3] Another difficulty is to distinguish between the question whether a conclusion is true in itself and the question whether the conclusion follows from the data. Notice the following reasoning:

All Anglosaxons are English;
All British are Anglosaxons;
Therefore, all English are British.

Here the conclusion is true in itself, but the "therefore" is false, since the conclusion does not follow from the data, which are themselves false in part. About a third of college students slipped up on this one. Though it may seem pedantic to quibble over the "therefore" if a true conclusion is reached, yet, as we shall soon see, some of the most important reasoning consists in drawing the consequences of statements that are not known to be true, and so checking up on those statements themselves. If an untrue conclusion follows logically

[3] M. C. Wilkins, *Archives of Psychology*, 1928, no. 102, pp. 27, 46.

from certain data, there must be something wrong with those data. Inference consists, not in seeing the truth of the conclusion, but in seeing whether the conclusion is present in the pattern of the data.

The reasoner needs a clear head and a steady eye; he needs to look squarely at his data, to keep extraneous matter out of the pattern that he is trying to discern, and to see the pattern whole, instead of hastily responding to a fraction of it. Diagrams and symbols often assist him in keeping the essential facts clear of extraneous matter.

To sum up: the process of reasoning culminates in two facts being present as stimuli, and the response, called "inference," consists in perceiving a third fact that is implicated in the two stimulus-facts. It is a good case of the law of combination, and at the same time it is a case where "isolation" is needed, otherwise the response will be partly aroused by irrelevant stimuli, and thus be liable to error.

Psychology and Logic. Psychology is not the only science that studies reasoning; that is the subject-matter of logic as well, and logic was in the field long before psychology. Psychology studies the *process* of reasoning, while logic checks up the result and shows whether it is valid or not. Logic cares nothing about the exploratory process that culminates in inference, but limits itself to inference alone.

Inference, in logical terminology, consists in drawing a conclusion from two given premises. The premises are the data which, acting together, arouse the response of seeing or inferring the conclusion. The two premises and the conclusion, set forth in order, constitute the syllogism. It is part of the business of logic to examine data to see whether they are sufficiently coherent to justify a conclusion. Logic points out the fallacies that may creep into the reasoning process, but it belongs to psychology to discover how troublesome those

fallacies are to the reasoner; some are easily avoided while some are veritable traps.

How inference is related to sense perception. As the culmination of observation is the perception of some pattern in the sensory data, so the culmination of the reasoning process is, as we have said, the seeing (figuratively) of some pattern in data assembled partly, at least, by recall from former experience. So there is a close relation between sense perception and reasoning, and inference is an extension of the pattern-grasping activity beyond the sensory field.

We can also trace a continuity between perception and inference along the line of sign and meaning. Learned perception, we said, consists in knowing an objective fact by aid of some sign. Now when the meaning of the sign is grasped instantly, as when we hear barking and know at once that a dog is near, we should speak of perception and not of inference, though, as a matter of logic, we could set down premises from which the conclusion followed; such as:

A certain rhythmical series of gruff sounds is always produced by a dog;
I hear rhythmical sounds of this character;
Therefore, I hear a dog.

Some psychologists, in times past, have even concluded that perception was a rapid and unconscious inference; but there is no excuse, in such an instance as the barking dog, for supposing the process to consist of a series of steps, the response is too direct. But now it may happen that you hear a noise that, while familiar, does not at once lead to a knowledge of its cause; you may then recall some former experience that suggests the meaning of this noise, and conclude accordingly. Here, since the process is indirect, and utilizes recalled data, it would scarcely be stretching the point to speak of a simple sort of inference; and from such simple cases we can trace

a continuous series extending to the most abstract reasoning imaginable.

Continuity between human reasoning and animal trial and error. We have sufficiently stressed the fact that the exploratory process in reasoning has much resemblance in form to trial and error behavior. Do animals reason? The experimental work on animal learning, reviewed in one of our earlier chapters, was begun with this question in mind. Previous evidence on this point had been limited to anecdotes, such as that of the dog that opened a gate by lifting the latch with his nose, and was supposed to have seen men open the gate in this way, and to have *reasoned* that if a man could do that why not a dog? The objection to this sort of evidence is that the dog's manner of acquiring the trick was not observed. You must experiment by taking a dog and showing him how to open the gate by lifting the latch; but it was found that dogs could not learn the trick in this way. If, however, you placed a dog in a cage, the door of which could be opened by lifting a latch, and motivated the dog strongly by having him hungry and placing food just outside, then the dog went to work by trial and error, and lifted the latch in the course of his varied reactions; and if he were placed back in the cage time after time, his unsuccessful reactions were gradually eliminated and the successful reaction was firmly attached to the situation of being in that cage, so that he would finally lift the latch without any hesitation.

The behavior of the animal does not look like reasoning. For one thing, it is too impulsive and motor. The typical attitudes of the reasoner, whether lost in thought or studying over things, do not appear in the dog, though traces of them are seen in the chimpanzee. There is nothing to indicate that the animal recalls facts previously observed and sees their bearing on the problem in hand.

The behavior of human beings, placed figuratively in a cage,

sometimes differs very little from that of an animal. Certainly it shows plenty of trial and error and random motor exploration; and often the puzzle is so blind that nothing but motor exploration will bring the solution. What the human behavior does show that is mostly absent from the animal is (1) attentive studying over the problem, scrutinizing it on various sides, in the effort to find a clue; (2) thinking, typically with closed eyes or abstracted gaze, in the effort to recall something that may bear on the problem; and (3) sudden "insights," when the present problem is seen in the light of past experience.

The gap between animal and human procedure in solving a problem is bridged in some measure by the evidence that we found of rudimentary observation in animals, by the facts of delayed response in monkeys, and by the signs of insight that were shown by the chimpanzee. Even confining ourselves to human behavior, we can trace out a long and continuous series, between almost random motor trial and error, and reasoning in its highest forms. The advance as we go up the scale of behavior consists of

(1) more observation and more seeing of patterns and relations;

(2) more use of recalled data;

(3) more system in following up clues, the false leads being eliminated partly by thinking them through and partly by trying them out and definitely checking them off as useless;

(4) the use of language as an aid to thought, either when people are working together over a problem, or when the individual is working alone.

Thought and language. From time to time, for the last two thousand years, some psychologist has arisen to say that thought consisted in inner speech. The evidence for this view is derived from the introspection of many people; and,

indeed, almost anyone will agree that he talks to himself, internally, when he is thinking over a difficult problem. He may catch himself arguing the matter pro and con, as if there were two voices inside of him. If he is alone, he may talk aloud, and use gestures. This common experience of men, along with the fact that man, the thinking animal, is also the talking animal, has led to the identification of thought with inner speech.

Now there is no doubt that language is a great aid to thought. First and most important, thinking develops very largely in social behavior. The child is stimulated to think by what other people say to him, and by his desire to explain his wants to other people. Discussion and argument stimulate thought, and it is interesting that the science of logic grew out of the debating-society habits of the Greeks.

When the individual is thinking alone, he is apt to have a social situation in the back of his mind, and to be in the attitude of preparing to defend his conclusions and make them count with somebody else.

Verbalizing the facts observed is an aid in remembering them, and verbal memory is an aid in the assembling of data from past experience for use in solving a present problem. If, in solving one problem, you have formulated in words any principles you may have discovered, these principles will be the more readily recalled when you later encounter a similar problem. Maxims, developed out of your own struggles in solving your problems, or handed down to you by your elders, are often recalled in the stress of fresh difficulties and serve as guides in exploring the situation. So, when you have lost something, the maxim to think where you used it last is often useful. A good stock of principles, formulated in handy words, is essential to one who would reason efficiently in any difficult field.

Words are symbols that we can substitute for real facts, and

with them carry on thinking in abridged form. Number words are the best illustration here. By knowing the meaning of the number words, by learning the addition and multiplication tables — jingles of words, to a large extent — and by following certain set rules of procedure, we are able to figure out number problems with a facility that is marvellous. Mathematics, as a whole, is the greatest achievement of human reasoning, and depends mostly on the use of symbols. These symbols, to be sure, are not wholly linguistic, since, though most of them have names, they are more essentially written characters, and few people can follow a mathematical process of reasoning that is conducted orally, without any aid from the eye. This instance leads us to suspect that thinking is just as much seeing as it is talking.

In spite of all that can be said in its favor, the thesis that thought = inner speech is probably wrong. Introspection, which certainly supports the proposition that much inner speech goes on in thinking, also shows that at certain times thought runs away from speech. When thought is very active, speech becomes fragmentary. Often one cannot instantly think of the name of an object, or doesn't bother to do so, as he knows perfectly well what he is thinking about and need not delay to think of the name. Silent reading gets through a page in a half or a third of the time that would be required for rapidly pronouncing the words. In reading aloud, you get the sense often as much as a whole line ahead of the voice. You can read aloud and be thinking of something entirely different. While making a speech, if you can "think on your feet," you think one thing while saying another.

Recording apparatus applied to the tongue and larynx shows that those organs make little movements much of the time, during thinking or otherwise, but does not show what you might expect. You might expect to find, during inner speech, movements like those of whispering, only smaller, but the

movements you get are irregular and apparently unrelated to the words thought of.[4] But this negative result does not help us much, for inner speech is certainly a fact, whether or not the tongue and larynx have anything to do with it.

There is one fact that is certain. In order to think a thought, it is not sufficient to say the words in which the thought is expressed. A boy learns his little speech thoroughly, goes on the platform before his schoolmates and rattles it off without the slightest sense of what he is saying. The same kind of thing is known to happen in church. It happens in reading a textbook; you may read a paragraph through aloud without getting an inkling of the author's thought, your own thoughts being far away. If there is any truth in what we have been reiterating, that the exploratory process of reasoning is preliminary to seeing something new, then we can conclude that speech plays its part in the preliminary stage. It helps greatly in assembling the data, but grasping the new knowledge present in the combined data is seeing, not talking.

Motivation of reasoning. The situation that arouses reasoning differs from one case to another, the motive for engaging in this rather laborious mental process differs, and the order of events in the process differs in consequence. There are several main types of reasoning, considered as a process of mental exploration.

1. Reasoning out the solution of a practical problem. A problem is a situation for which we have no ready and successful response. We must *find out* what to do. We explore the situation, partly by the senses and actual movement, partly by the use of our wits. We observe facts in the situation that recall previous experiences or previously learned rules and principles, and apply these to the present case. Many of these clues we reject at once as of no use; others we may try out

[4] A. M. Thorson, *Journal of Experimental Psychology*, 1925, vol. 8, pp. 1–32.

and find useless; some we may think through and thus find useless; but finally, if our exploration is successful, we observe a real clue, recall a pertinent guiding principle, and see the way out of our problem.

Two boys went into the woods for a day's outing. They climbed about all the morning, and ate their lunch in a little clearing by the side of a brook. Then they started for home, striking straight through the woods, as they thought, in the direction of home. After quite a long tramp, when they thought they should be about out of the woods, they saw clear space ahead, and, pushing forward eagerly, found themselves in the same little clearing where they had eaten their lunch! Reasoning process No. 1 now occurred: one of the boys *recalled* that when traversing the woods without any compass or landmark, the traveller is very likely to go in a circle; inference, "That is what we have done and we probably shall do the same thing again if we go ahead. We may as well sit down and think it over."

Mental exploration ensued. "How about following the brook?" "That won't do, for it flows down into a big swamp that we couldn't get through." "How about telling directions by the sun?" "But it has so clouded over that you can't tell east from west." "Yes, those old clouds! How fast they are going! They seem to go straight enough." "Well, say! How about following the clouds? If we keep on going straight, in any direction, we shall surely get out of the woods." This seems worth trying and actually brings the boys out to a road where they can inquire the way home.

What we find in this case is typical of problem solution. First, a desire is aroused, and it facilitates the observation and recall of facts relevant to itself. One pertinent fact is observed, another pertinent fact, or rule, is recalled; and in these two taken together the key to the problem is found.

2. *Rationalization or self-justification.* While in the preceding case reasoning showed what to do, here it is called upon to justify what has been done. The question is, what reason to assign for our act; we feel the need of meeting criticism, either from other people or from ourselves. The real motive for the act may be unknown to ourselves, as it often is unless we have made a careful study of motives; or, if known, it may not be such as we care to confess. We require a *reasonable* motive, some acceptable general principle that explains our action.

A child is unaccountably polite and helpful to his mother some day, and when asked about it replies that he simply wants to help — while his real motive may have been to score against his brother or sister, who is to some extent his rival.

If I have work requiring attention but want to go to the game, I should certainly be lacking in reasoning ability if I could not find something in the situation that made my attendance at the game imperative. I am stale, and the game will freshen me up and make me work better afterward. Or, I am in serious danger of degenerating into a mere "grind," and must fight against this evil tendency. Or, my presence at the game is necessary in order to encourage the team.

Thus, aspects of the situation that are in line with our desire bob to the surface and suggest acceptable general principles that make the intended action seem good and even necessary. Man is a rationalizing animal as well as a rational animal, and his self-justifications and excuses, ludicrous though they often are, are still a tribute to his very laudable appreciation of rationality.

3. *Explanation.* This form of reasoning, like the preceding, takes its start with something that raises the question, "Why?" Only, our interest in the question is objective rather than subjective. It is not our own actions that call for explanation, but some fact of nature or of human behavior.

Why is it so cold in January? The fact arouses our curiosity. We search the situation for clues, and recall past information, just as in the attempt to solve a practical problem. "Is it because there is so much snow in January?" "But what, then, makes it snow?" This clue heads us in a circle. "Perhaps, then, it is because the sun shines so little of the time." That is a pretty good clue; it recalls the general principle that, without a continued supply of heat, cold is inevitable. To explain a phenomenon is to deduce it from an accepted general principle, and such explanation is very satisfactory, since it rids you of uncertainty and sometimes of fear, and gives you a sense of power and mastery.

4. Application. While the reasoning processes thus far discussed have taken their start with the particular case and hunted for a general principle to fit the case, reasoning may also take its start at the other end. It may start from the general principle and seek for particular cases belonging under it. But what can be the motive for this sort of reasoning? What is there about a general proposition to stimulate exploration?

The motive may be that of seeing the application of the principle. Somebody whose authority you fully accept enunciates a principle, and you wish to see how it applies to particular cases; you may have hopes of putting it to practical use, or you may simply wish to make its meaning more real and concrete. You search your memory, this time, for concrete instances where the accepted principle should apply. If the general proposition is that birds and mammals are the only warm-blooded animals, then fish and frogs and lizards are cold-blooded, spiders, insects, lobsters and worms; these inferences give you a more realistic understanding of the general proposition.

Under the head of application belongs *prediction.* The general principle, applied to a particular situation, enables you

to predict the outcome of the situation. Thus the astronomer successfully predicts eclipses, the physician the course of a fever and the results to be expected from certain treatment, and the engineer the strength of his bridge or the current to be produced by his dynamo. If you can predict, you can control, so that there is plenty of motivation for this type of reasoning.

5. *Doubt.* A general proposition may stimulate reasoning because you doubt it and wish to find cases where it breaks down. Perhaps somebody makes the general statement whose authority you do not accept; perhaps he says it in an assertive way that makes you want to take him down a peg. Perhaps you are in the heat of an argument with him, so that every assertion he may make is a challenge. You search your memory for instances belonging under the doubted general statement, in the hope of finding one where the general statement leads to a result that is contrary to fact. "You say that all politicians are grafters. Theodore Roosevelt was a politician, therefore, according to you, he must have been a grafter. But he was not a grafter, and you will have to take back that sweeping assertion."

6. *Verification.* This doubting type of reasoning has much more serious uses; for this is the method by which a *hypothesis* is tested in science. A hypothesis is a general proposition put forward as a guess, subject to verification. If verified, it will be accepted as a "law of nature," but at the outset it is only a guess that may turn out to be false. How shall its truth or falsity be demonstrated? By deducing its consequences, and checking them against observed facts.

An example from the history of science is afforded by Harvey's discovery of the circulation of the blood, which was at first only a hypothesis, and a much-doubted one at that. If the blood is driven by the heart through the arteries, and returns to the heart by way of the veins, then the flow of blood

in any particular artery must be away from the heart, and in any particular vein towards the heart. This deduction was readily verified. Further, there should be little tubes leading from the smallest arteries over into the smallest veins, and this discovery also was later verified, when the invention of the microscope made observation of the capillaries possible. Other deductions also were verified, and in short all deductions from the hypothesis were verified, and the circulation of the blood became an accepted law.

Most hypotheses are not so fortunate as this one; most of them die by the wayside, after a shorter or longer career. Born of a few facts, they ventured forth like knights into the world with a challenge to all comers, and held their own for a time, only to be slain at last by some unexpected fact that their challenge had stirred up. Hypotheses, even when destined to die, are useful to science as stimuli to observation. The psychological process of scientific discovery is about as follows. You start with some observed facts that seem queer to you (such as the apple falling to the earth while the moon keeps sailing around it), and try to find some accepted law that can explain them. If you find no such law in existence, you are driven to guess at a new law, or hypothesis, that fits all the facts known to you. Now, if you have the scientific spirit, you put a big question mark after your beautiful hypothesis, and proceed to check it up against new facts yet to be discovered. You are guided toward the discovery of pertinent new facts by reasoning about your hypothesis and deducing its consequences; you see that, *if* the hypothesis is true, such and such facts must be true. Next you go out and observe whether the predicted facts are to be found, and if they are found your hypothesis is verified to that extent, though it may be upset later. If the deduced facts are not true, the hypothesis is false, and you have to begin all over again.

The would-be natural scientist may fail at any one of several points. First, he may see no question that calls for investigation. Everything seems a matter-of-course, and he concludes that science is complete, with nothing left for him to discover. Second, seeing something that still requires explanation, he may lack fertility in guessing. Helmholtz, an extremely fertile inventor of high-grade hypotheses, describes how he went about it. He would load up in the morning with all the knowledge he could assemble on the given question, and go out in the afternoon for a leisurely ramble; when, without any strenuous effort on his part, the various facts would get together in new combinations and suggest explanations that neither he nor any one else had ever thought of before. Third, our would-be scientific investigator may lack the clear, steady vision to infer the consequences of his hypothesis; and, fourth, he may lack the enterprise to go out and look for the facts that his hypothesis tells him should be found.

CONCEPTS AND THEIR DEVELOPMENT

An important tool in thinking is the concept, which, in more familiar language, is the idea you have of anything. The concept is not any single memory image that you call up of an object, nor any single motor response you make to it. Rather, the concept is the sum total of what you know about the object: how it looks, how it sounds, how it smells, tastes and feels, what it does and what you and other people do to it. The concept, then, is the sum total of what you have retained from observing, dealing with and thinking about the object. Your concept of anything is what the thing means to you. Anything that can be perceived by the senses, or thought of, or imagined, can be conceived — persons, things, events, qualities and relations, concrete or abstract, individual or general.

To be a tool of thought, a concept needs to have some unity and some freedom. The various items included in it need to be linked together by observation of their all belonging to the same object. The responses you make to the object must have come to your attention. The concept of air, for example, is a difficult one for the child to form, though he deals with the air from the moment of birth, inhaling and exhaling it, operating his vocal cords with it, and doubtless feeling it pass through his throat. Air in motion, air that feels cold or that makes a noise, he knows when two or three years old, but the notion of quiet air, filling the room, and breathed in and out, he does not get till several years later. He needs to know still air in order to tie up the wind and his own breathing into a single concept. He needs, not simply to breathe, but to observe his breathing, in order to have a concept of that process.

Development of concepts in the little child. Until the child can talk, it is difficult to trace the development of his concepts, though he probably does some thinking and forms some concepts before he begins to talk. The sight of a person early becomes a conditioned stimulus for getting ready for what the person is going to do to him, and as soon as he can definitely *anticipate* what the person is going to do, he certainly has a rudimentary concept of that person. And so of things. As soon as he definitely anticipates the noise a spoon will make when dropped on the floor, he knows something about spoons and thus has a rudimentary concept of that class of objects. Definite anticipations mark the beginning of "free ideas." Anticipation also shows that at least two facts observed about the same object have been linked together. Therefore the child's behavior, even before he starts to talk, strongly suggests that he is already building up concepts. The child's concept of a thing centers around what he does with the thing and what it does to him.

When the child begins to understand words, and, soon afterwards, to say them, he is being handed the names that go with concepts current in his social environment, and we can judge, from his growing vocabulary, which of these concepts he acquires more readily than others. We have to be on our guard somewhat, for the child may use a word without having any clear idea of its meaning. A child will pick up number words, for example, and connect them vaguely with each other, with the clock, and with such questions as "How many?" or "What time is it?" and still use them so indiscriminately that he certainly does not appreciate their exact meaning; and he probably does not possess at this age any definite number concepts beyond those of one and two. But as a rule the child uses his words correctly enough to warrant us in accepting them as evidence of concepts.

The vocabulary of a certain little girl of two-and-a-half years contained 500 words, of which no less than 300 were nouns, mostly names of persons or things. Now persons and things *stand out* from their surroundings, and move or are moved about in their surroundings, so that they are readily isolated as figures; and this is probably the reason for the predominance of names of persons and things in the child's early vocabulary. Parts of a thing do not come off, physically, so that it is difficult to see them as definite figures, to do anything with them, or to form concepts of them. The first parts to be named by the child are parts of himself, the nose, mouth, hand, thumb, toe. In the vocabulary of 500 words, about the only names of other parts were "cover" (which does come off) and "handle" (to which you do definitely respond).

Of the 500 words, only 70 were adjectives. To use an adjective is to have some conception of a quality of a thing, and qualities do not come off. The first adjectives to appear in the child mentioned were "hot," "clean," "sticky" (for dirty),

"gone" and "broken," all referring to qualities having some practical concern for the child. Among the adjectives at two-and-a-half years were several color names: white, black, red, yellow, green, blue, gray, brown, pink. The child learned color names easily enough, and used them in answer to the question, "What color is that?" But it was more than two months after she had acquired this whole stock of color names before she began to use any of them correctly. She answered "pink" or "brown" or "white" or "blue" indiscriminately, when the color of a present object was asked for. By gradual improvement during a period of several months she finally came to use the names precisely, first red, black and white soon after, with the rest trailing. Colors, while serving as important signs of other facts, are not in themselves a matter of practical concern to the child; and for that reason definite color concepts are acquired rather slowly.

Relations are, if anything, still more subtle and hard to isolate than qualities, and few relation words appear in the child's early speech. Those that appear first express spatial relations, as "on," "in," "to," "around," "over," "away," "far," "farther." The child also expresses the relations of likeness and difference, more and less, mine and thine, mother and child.

Action words — verbs — appear in the child's speech as early as nouns, the same word, as "barking," often doing duty both for an object and its action. "Thank you" is readily learned, and applied to the situation of giving and receiving, but the child is apt to say it when he hands you something as well as when you hand something to him. In the vocabulary of 500 words there were 80 verbs, mostly names for the child's own actions or for actions that are performed upon him (as "carry," "tickle"). The actions of inanimate things are usually called, at this age, by the names of human actions, and the only clear instances in this child's vocab-

ulary of strictly objective action words were "break" and "bounce."

We observe two factors of advantage in this early development of concepts. What stands out in sense perception has the advantage in concept formation, and what the child deals with in a motor or practical way has the advantage.

Further development of the child's concepts. Interesting studies of children's concepts of the physical world, between the ages of three and twelve, have been made by listening to their questions and by quizzing them.[5] Surrounded as he is with people and with man-made objects, he falls readily into an animistic and purposivistic view of natural phenomena. Young children define objects in terms of use. A fork is "to eat with," a chair "to sit on," a mother "to take care of you"; and similarly, a mountain is "to climb up," clouds are "to give rain and water the flowers," the sun is "to warm you," the lake is "for the fishes to live in." These natural objects, serving the needs of man, are conceived, more or less vaguely, as man-made. The lake must have been dug by workmen and then filled with water. At the same time, they are conceived as living and acting of themselves. When children of different ages are asked what things are alive and can feel, their answers indicate a gradual development from animistic to more mechanistic conceptions of nature, passing through a series of stages which however are not closely bound up with definite ages, since some children progress in this respect much faster than others.

In the first stage, everything is alive and can feel:

Does a stone feel the cold? *No.* — Would it feel if it was dropped on the ground? *Yes, because it would break.* — Can a table feel anything? *No.* — Would it feel if it were being broken? *Oh, yes.* — Does the wind feel when it blows against a house? *Yes, because it is in its way. It can't pass. It can't go any further.* — Do walls feel?

[5] See especially, J. Piaget, *The Child's Conception of the World*, 1929.

No. Why not? *Because they can't move.* Would they feel anything if they were knocked down? *Yes.*

In the second stage, anything can feel when it moves:

Does the sun know anything? *Yes, it heats.* — Does it know that it's hidden from us in the evening? *Yes, because it sees the clouds in front of it. . . . no, it doesn't know, because it isn't the sun that hides. It's the clouds that go in front of it.* — Does a bicycle know when it goes? *Yes it feels the ground.* — Does a motor know it goes? *Yes it feels it isn't still in the same place.*

In the third stage, things feel when they move *of themselves:*

Would a table feel if I were to prick it? *No, because it is not a person.* — Does the wind feel when it is blowing? *Yes.* — Does the sun feel anything? *Yes, it feels it's heating.* Can the wind feel anything? *Yes, because it blows.* — Can the water feel anything? *Yes, because it flows.* — Does a bicycle know when it goes? *No, because it has to be made to go.*

Or, again, from a boy of twelve

Is a fly alive? *Yes, because if it wasn't alive it couldn't fly.*
Is a bicycle alive? *No, because it's we who make it go.*
Are clouds alive? *Yes — no, they're not. If they were alive, they would come and go as they wanted. It's the wind that drives them.*
Is the wind alive? *Yes, because it's the wind that drives the clouds.*
Are streams alive? *Yes, because the water is flowing all the time.*
Is an automobile alive? *No, it's the engine that makes it go.*
Is the engine alive? *No, it's man who makes the engine go.*
Is the sun alive? *Yes, it makes the sunshine and gives light.*

A further stage would be a mechanistic conception of the movements of all inanimate things, and this is about as far as most individuals go in this direction.

Egocentric and objective concepts. The difficulties with which the child labors in reaching objective concepts are well illustrated in the case of the apparent motion of the sun or

moon. The child sees the sun or moon move with him when he walks. It seems that he makes them move, or else that they follow him so as to stay with him. This "egocentric" conception is flattering to his self-esteem, and at the same time the easiest and most direct reading of the observed facts. The child has the same difficulties, in a small way, that the whole civilized world had about 1600 in giving up the man-flattering and obvious geocentric conception of the universe for the Copernican conception. It takes a wrench to conceive of the earth as moving around the sun, and as being not the center of all things but only a small element in a much bigger system.

The individual's own dealing with things necessarily centers in himself, and to conceive of things as centered anywhere else, or as not centered at all, seems to him at first utterly unpractical, though the objective concepts obtained by thinking from some other center than oneself are often extremely practical in the long run. The child is early forced to get beyond himself in his conceptions of objects. A ball may be to him at first just "something to throw," but after it has left his hands he sees it roll and bounce. Some one else picks it up and will not give it to him, and he sees balls in the store that he "mustn't touch." So he is led, and driven, to an objective conception of a ball as having certain properties independent of him and his responses to it. An egocentric concept is one which relates the object to the individual himself, while an objective concept relates one object to another. The child is led and forced to observe things acting upon each other, or otherwise related to each other, and so he early makes a start in the formation of objective concepts.

The concept, to be a tool of successful thinking, has to "work." It has to work in thinking how to use physical objects, and is checked up by the physical environment; and it has to work in conversation with other people, and is checked

up by the social environment. The physical environment insists on objectivity of concepts, and the social environment insists on their conformity with the accepted ideas of the social group. By degrees, then, some of the child's concepts become objective, while others come to accord with the concepts of the culture in which he is growing up. These socially accepted concepts are often far from objective; in many cultures, for instance, animistic views of natural phenomena are standard, and the child is thus confirmed in the animistic concepts which seem to be the line of least resistance in his early thinking about the world.

Generalization of concepts. Since what is observed is always some particular ball or dog or person, the question arises how the child ever comes to his concepts of a class of objects,— balls, dogs or persons in general. We might suspect that it would be a slow and difficult process for him to advance from concepts of this, that and the other particular dog to the concept of dogs as a class. But to quite an extent generalizing is the line of least resistance. Things that are alike he responds to alike, and this community of response ties them together into a class. The child's spontaneous extension of the meaning of names reveals the ease with which he generalizes. He calls a strange man "papa"; the first time he sees a squirrel, he calls it a "funny kitty." He reacts to the new object as he has learned to react to similar objects. It is a case of reduced cues, again: the new stimulus has enough in common with the old to arouse the same response. When a certain response has worked well in one case, it is apt to be made in a similar case, and some environmental check-up in the form of failure or ridicule is needed to break up the broad class of objects into sub-classes. Such is generalization of the practical sort, but to reach an intellectual generalization, a real concept of the class of objects, some freedom of thought, some separation from motor response, is necessary.

A start towards this freedom is seen in what is called *association by similarity*. One thing makes you think of another similar thing that you have known. One person reminds you of another. Now if, on sight of a person who resembles your old friend, you impulsively rush up and grasp his hand, only to be received with wonder, that is simply a motor response to a reduced cue. But if you check your motor response and say to yourself that this stranger resembles your friend, that is association by similarity — a more complex response, since you are thinking of two people instead of only one, and since you are aware of some difference between them as well as of their resemblance. Such association by similarity leads you to recognize the existence of similar objects that are not identical, and so leads to the concept of a class of similar objects. But another step, and a long one, is necessary before you can define this class, or before you see exactly how the similar objects are similar. Analysis is necessary.

Analysis and definition. To define a concept, you must discover what is common to all objects covered by the concept, without being common at the same time to other objects that do not belong under the concept. A chair is "to sit on," but you can sit on any number of other things. Chairs themselves vary from one another in many ways, and any one chair has characteristics that are not found in all chairs, and that therefore do not belong in the concept of a chair. The difficulty is to peel off from a chair, in thought, something that does not come off physically, namely the essential characteristics of a chair. It is a task of isolation.

Isolation by varying concomitants is the phrase used for one condition under which the difficult job of analysis can be achieved. Along with the essential feature which is present in all objects belonging to the class are concomitant features, varying from one particular object to another. Several chairs are shown, differing in all sorts of ways from one another, ex-

cept in the essentials of a chair. Then the essential feature seems to loosen and thus become easier to peel off or isolate. The common feature has the advantage of frequency, and so becomes more closely linked with the response of saying "chair." If only one object is present at a time, and memory is depended on to recall the others, the recall of an object, being often incomplete, may contain only the frequently seen common feature, and the incompleteness of recall may favor analysis.

Isolation by trial and error. An individual who has to respond to all the objects of one class in one way — as by giving each one the class name, or by handling it properly — and to other objects differently, makes errors at first, but being checked up by his failures, is stimulated to analysis. After a failure, he may wonder what was wrong, look more sharply, and seek some clue that will guide his future responses. Or, if he has been failing repeatedly, and suddenly meets with success, he wonders how this can be, and looks sharply for the cause of his unexpected success.[6] If his rule has been working well, and suddenly encounters a "negative instance," the logical thing for him to do is to look for some clue that will enable him to change his rule, but there is often an inertia, or a fondness for the rule that one has adopted, which makes it almost impossible to give it up.[7] If the essential feature that needs to be isolated is presented clearly, with few complications — as a chair with few distracting inessentials — then the task of isolation is simplified.[8] These are just a few results from experimental studies that are seeking to unravel the complex process of concept formation.

[6] E. Heidbreder, "An Experimental Study of Thinking," *Archives of Psychology*, 1924, no. 73, pp. 104, 168.

[7] H. A. Ruger, *The Psychology of Efficiency*, 1910, p. 30; Z. Y. Kuo, "Behavioristic Experiments on Inference," *Journal of Experimental Psychology*, 1923, vol. 6. pp. 247–293.

[8] C. L. Hull, "Quantitative Aspects of the Evolution of Concepts," *Psychological Monographs*, 1920, no. 123.

As can readily be believed, the process of reaching true, adequate, objective concepts of people, things, and natural and social phenomena is long and tortuous. Humanity has been engaged upon it since the beginning, though not always with a thoroughly objective slant. Negative instances have often been glossed over and traditional conceptions adhered to in spite of evidence to the contrary. A false conception, analogous to an illusion in the field of perception, may be called a misconception, or in extreme cases a delusion. Something will be said of delusions under the head of autistic thinking in the following chapter; and, in general, our topic of thinking continues right along into the next topic of imagination.

EXERCISES

1. Show that both freedom and control are necessary for productive thinking.

2. Assemble and compare the various lists of "factors of advantage" that have been given in different chapters.

3. Assemble and compare the various instances in which a "set" has been found important in determining what response shall be made to a stimulus.

4. Trial and error in motor behavior, in perception, and in reasoning.

5. What is your own reaction to the proposition that thought consists in inner speech?

6. How is it that superstitions like that of Friday being unlucky persist from generation to generation? If such a belief were treated as a hypothesis, how could it be tested?

7. The motivation of belief and of doubt.

8. Introspective reports of the reasoning process. Attempt to solve some of the following problems, and record immediately afterward what you can observe of the process.

   (a) What can be meant by saying that a certain person "cannot be a thinker, he is too positive in his opinions"?

(b) Why does the full moon rise about sunset?

(c) Which would be the greater misfortune, to exhaust all the coal mines, or all the iron mines?

(d) What is it that has four fingers and a thumb, but no flesh or bone?

(e) A riddle: "Sisters and brothers have I none, yet this man's father is my father's son."

9. Can you find any traces of an animistic view of natural phenomena in the way adults speak of them or behave towards them?

10. Illustrate the importance of "association by similarity" in thinking.

REFERENCES

Most books on thinking approach the subject from a philosophical, social, or logical, rather than from a strictly psychological point of view; but the following will be found suggestive and stimulating to the psychologist:

E. Rignano, *The Psychology of Reasoning,* 1923 — reasoning as mental or imaginary experimentation.

G. Wallas, *The Art of Thought,* 1926 — the need for thought in society, and the means of fostering it.

L. Buermeyer and others, *An Introduction to Reflective Thinking,* 1923 — historical instances of productive thinking analyzed.

J. Dewey, *How We Think* — the logic and psychology of thinking.

J. H. Robinson, *The Mind in the Making,* 1921 — the development of realistic concepts in the history of European thinking.

CHAPTER XI

IMAGINATION

MENTAL AS DISTINGUISHED FROM MOTOR MANIPULATION

From discovery we now turn to invention, from exploration to manipulation.

The human enterprise of exploration, which we have examined under the headings of observation and reasoning, runs the gamut from simple exploratory movements of the sense organs in looking and listening, to the elaborate scientific procedure followed in testing hypotheses and discovering the laws of nature. Inventive or manipulative activity runs a similar gamut from the child's play with his toys to the creation of a work of art, the designing of a work of engineering, the invention of a new machine, or the organization of a new government. The distinction between the two lines of activity is that exploration seeks what is there, and manipulation changes it to something else. Exploration seeks the facts as they exist, while invention modifies or rearranges the facts. The two enterprises go hand in hand, however, since facts must be known to be manipulated, while on the other hand manipulation of an object brings to light facts about it that could never be discovered by simple examination. Invention is based on science and also contributes to the advance of science.

Manipulation and exploration certainly go hand in hand in the little child's behavior. The baby picks up his new toy, turns it about and examines it on all sides, shakes it and is pleased if it makes a noise, drops it and is pleased with its

bang on the floor. This is manipulation, certainly; but it is also a way of exploring the properties of the toy.

BEGINNINGS OF IMAGINATION IN THE CHILD

Beginning with grasping, turning, shaking and dropping of objects, the child's manipulation develops in several directions. One line of development leads to *manual skill.* The child learns to manage his toys better.

A second line of development is in the direction of *constructiveness.* Taking things apart and putting them together, building blocks, assembling dolls into "parties," are examples of this style of manipulation, which calls less for manual dexterity than for seeing ways in which objects can be rearranged.

Make-believe is a third direction followed in the development of manipulation. The little boy puts together a row of blocks and pushes it along the floor, asserting that it is a train of cars. The little girl lays her doll carefully in its bed, saying "My baby's sick; that big dog did bite him." This amounts to manipulating things according to the *meanings* attached to them, the blocks being treated as cars, and the doll as a sick baby.

Perhaps a little later than make-believe to make its appearance in the child is *story-telling,* the fourth type of manipulation. Where in make-believe he has an actual object to manipulate, in story-telling he simply talks about persons and things and makes them perform in his story. He comes breathless into the house with a harrowing tale of being pursued by a hippopotamus in the woods; or he gives a fantastic account of the doings of his acquaintances. For this he is accused of being a "little liar," or more charitably described as unable to distinguish observation from imagination; but really what he has not yet grasped is the *social* difference between his make-believe, which no one objects to, and his story-telling, which may lead people astray.

Both make-believe and story-telling are a great convenience to the child, enabling him to manipulate big and important objects that he could not manage in sober reality. He thus finds an outlet for desires that are blocked in sober reality — blocked by the limitations of his environment, blocked by the opposition of other people, blocked by his own weakness. Unable to go hunting in the woods, he can play hunt in the yard; unable to go to war with the real soldiers, he can shoulder his toy gun and campaign all about the neighborhood. The little girl of four years, hearing her older brothers and sisters talk of their school, has her own home work in "joggity," and her own graduation exercises.

PRELIMINARY DEFINITION OF IMAGINATION

In such ways as we have been describing, the little child shows "imagination," or mental manipulation. In story-telling the objects manipulated are simply *thought of;* in make-believe, though there is actual motor manipulation of present objects, the attached *meanings* are the important matter; and in construction there is apt to be a *plan* in mind in advance of the motor manipulation, as when you look at the furniture in a room and consider possible rearrangements.

The materials manipulated in imagination are usually facts previously perceived, and to be available for mental manipulation they must now be recalled; but they are not merely recalled — they are rearranged and give a new result. A product of imagination is composed of parts perceived at different times and later recalled and combined, as a centaur is composed of man and horse, or a mermaid of woman and fish. Imagination is like reasoning in using recalled facts; but it differs from reasoning in being manipulation rather than exploration; reasoning consists in seeing relationships that exist between facts, and imagination in putting facts into new relationships. These are but rough distinctions and definitions;

we shall try to do a little better after we have examined a variety of imaginative performances.

Imagination and invention are much the same, though imagination means rather the mental process itself, and invention the outcome of the process, which is a product having some degree of novelty and originality.

Imagination, like association, is sometimes free, and sometimes controlled. Controlled imagination is directed towards the accomplishment of some desired result, while free imagination wanders this way and that, with no fixed aim. Controlled imagination is seen in planning and designing; free imagination occurs in moments of relaxation, and may be called "play of the imagination." The free variety, as the simpler, will be considered first.

Our study will have more point if we first remind ourselves what are the psychological *problems to be attacked* in studying any mental activity. What is the *stimulus,* and what the *response?* These are the fundamental questions. But the study of response breaks up into three subordinate questions, regarding the *motivation,* regarding the *end-result* obtained, and regarding the often complex *process,* or series of responses, that leads to the end-result.

The response in imagination we have already defined, in a general way, as mental manipulation, and the end-result as the placing of facts into new combinations. The stimulus to actual combination consists of the facts, either perceived at the moment or recalled from past perception, that are now freshly combined. The more precise question regarding the stimulus is, then, as to what sort of facts make us respond in an inventive or imaginative way; and the more precise question regarding the end-result is as to what kind of patterns are given to the facts — both pretty difficult questions. In regard to process, the great question is as to how any one can possibly

escape from the beaten track of habit, and do anything new; and in regard to motivation the question is as to what goals are sought in inventive activity. This last question, as to *why* we imagine, is about the easiest to answer.

PLAY

Free imagination was spoken of a moment ago as a kind of play; and we might turn this about and say that play, usually if not always, contains an element of imagination or invention. Sometimes the child makes up new games, very simple ones of course, to fit the materials he has to play with; but even when he is playing a regular game, he has constantly to adapt himself to new conditions as the game-situation changes. We may take the child's play as the first and simplest case of free invention and ask our questions regarding it. What are the child's play-stimuli (toys), how does he manipulate them, what end-results does he reach, and what satisfaction does he derive from playing?

What is a toy? Anything to play with. But what characteristics of an object make it a real toy, which shall actually arouse the play response? First, it must be such that the child can move it; and almost anything that he can move serves, one time or another, for a plaything. But the surest stimulus is a *new* toy, the element of novelty and variety being important in arousing manipulation as it is in arousing exploration. However, to define a toy simply as something movable, and also new if possible, fails to satisfy the spirit of inquiry, and about the only way to progress further is to make a long list of toys, and classify them from the psychological point of view. Thus we get the following classes of play-stimuli:

Little models of articles used by adults, such as tools, furniture, dishes; and we might include here dolls and toy animals. The child's response to this class of toys is imitative. Some psychologists have been so much impressed with the imitative

play of children and animals (as illustrated by puppies playing fight), that they have conceived of all play as a sort of rehearsal for the serious business of life; but this conception does not apply very well to some of the other sorts of toy.

Noise-makers: rattle, drum, bell, horn, whistle, firecracker.

Things that increase your speed of locomotion, or that move you in unusual ways, as bicycle, skate, sled, rocking-horse, swing, seesaw, merry-go-round. Here belong also such sports as hopping, skipping, jumping, dancing, skipping rope, vaulting, leapfrog, whirling, somersault. The dizzy sensation resulting from stimulation of the semicircular canals is evidently pleasant to young children, and some of their sports seem aimed at securing a good measure of it.

Things that increase your radius of action; balls to throw or bat, bow and arrow, sling, mirror used to throw sunlight into a distant person's eyes; and we might include the bicycle here as well as in the preceding class.

Things that resist the force of gravity, floating, soaring, balancing, ascending, instead of falling; or that can be made to behave in this way. Here we have a host of toys and sports: balloons, soap bubbles, kites, rockets, boats, balls that bounce, tops that balance while they spin, hoops that balance while they roll, arrows shot high into the sky; climbing, walking on the fence, swimming, swinging, seesaw again.

Things that move in surprising ways or that are automatic: toy windmills, mechanical toys.

Things that can be opened and shut or readjusted in some similar way: a book to turn the leaves of, a door to swing or to hook and unhook, a bag or box to pack or unpack, water taps to turn on or off (specially on).

Plastic materials, damp sand, mud, snow; and other materials that can be worked in some way, as paper to tear or fold, stones or blocks to pile, load or build, water to splash

or pour; and we might add here fire, which nearly every one, child or adult, likes to manage.

Finally, playmates should really be included in a list of playthings, since the presence of a playmate is often the strongest stimulus to arouse play.

Such being the stimulus, what is the play response? It consists in manipulating or managing the plaything so as to produce some interesting result. The hoop is made to roll, the kite to fly, the arrow to hit something at a distance, the blocks are built into a tower or knocked down with a crash, the mud is made into a "pie," the horn is sounded. Many games are variations on pursuit and capture (or escape): tag, hide-and-seek, prisoner's base, blind man's buff, football. Wrestling, boxing, snowballing are variations on attack and defense. A great many are variations on action at a distance, of which instances have already been cited from children's toys; in adult games we find here golf, croquet, bowling, quoits, billiards, shooting. Many games emphasize motor skill, as skipping ropes, knife, cat's cradle, usually however with competition in skill between the different players. This element of manual skill enters of course into nearly all games. Mental acuteness appears in the guessing games, as well as in chess and many games of cards. Many games combine several of the elements mentioned, as in baseball we have action at a distance, pursuit and escape, motor skill and activity, and a chance for "head work."

THE PLAY MOTIVES

Now, what is the sense of games and toys, what satisfactions do they provide? There is no one single "play instinct" that furnishes all the satisfaction, but conceivably every natural and acquired source of satisfaction is tapped in one play or another. In the games that imitate fighting, some of the joy of fighting is experienced, even though no real anger develops. In the games that imitate pursuit and escape, some

of the joy of hunting and some of the joy of escape are awakened. In the kissing games that used to be common in young people's parties when dancing was frowned upon, and in dancing itself, some sex gratification is undoubtedly present; but dancing also gives a chance for muscular activity which is obviously one source of satisfaction in the more active games. In fact, joy in motor activity must be counted as one of the most general sources of play-satisfaction. Another general element is the love of social activity, which we see in dancing as well as in nearly all games and sports. Another, akin to the mere joy in motor activity, is the love of manipulation, with which we began this whole discussion.

The " escape motive " deserves a little more notice. Though you would say at first thought that no one could seek fear, and that this emotion could not possibly be utilized in play, yet a great many amusements are based on fear. The chutes, scenic railways, roller coasters, etc., of the amusement parks would have no attraction if they had no thrill; and the thrill means fear. You get some of the thrill of danger, though you know that the danger is not very real. Probably the thrill itself would not be worth much, but being quickly followed by *escape,* it is highly satisfactory. The joy of escape more than pays for the momentary unpleasantness of fear. Fear is utilized also in coasting on the snow, climbing, swimming, or any adventurous sport: in all of them there is danger, but the skilful player escapes by his own efforts. If he lost control he would get a tumble; and that is why the sport is exciting and worth while. He has his fear in check, to be sure, but it is awakened enough to make the escape from danger interesting. Nothing could be much further from the truth than to consider fear as a purely negative thing, having no positive contribution to make to human satisfaction. Though we try to arrange the serious affairs of life so as to avoid danger entirely, in play we seek such dangers as we can escape by skilful

work. The fascination of gambling and of taking various risks probably comes from the satisfaction of the fear and escape motive.

But of all the "dependable motives," it is self-assertion or mastery that comes in oftenest. Competition, one form of self-assertion, is utilized in a tremendous number of games and sports. Either the players compete as individuals, or they choose sides and compete as teams. No one can deny that the joy of winning is the high light of play. Yet it is not the whole thing, for the game may have been worth while, even if you lose. Provided you can say, "Though I did not win, I played a good game," you have the satisfaction of having done well, which is the mastery satisfaction in its non-competitive form.

All toys that enable you to act at a distance, or to move rapidly, gratify the mastery impulse. Imitative play does the same, in that it enables the child to perform, in make-believe, the important deeds of adults. Children like to play at being grown-up, whether by wearing long dresses or by smoking, and it makes them feel important to do what the grown-ups do; you can observe how important they feel by the way they strut and swagger.

All in all, there are several different ways of gratifying the self-assertive or mastery impulse in play: always there is the toy or game-situation to master and manage; often self-importance is gratified by doing something big, either really or in make-believe; and usually there is a competitor to beat.

EMPATHY

There is still another possible way in which play may gratify the mastery impulse. Why do we like to see a kite flying? Of course, if it is *our* kite and we are flying it, the mastery impulse is directly aroused and gratified; but we also like to watch a kite flown by some one else, and similarly we like to watch a hawk, a balloon or aëroplane, a rocket. We like also

to watch things that balance or float or in other ways seem to be superior to the force of gravity. Why should such things fascinate us? Perhaps because of *empathy,* the "feeling oneself into" the object contemplated. As sympathy means "feeling with," empathy means "feeling into," and the idea is that the observer projects himself into the object observed, and gets some of the satisfaction from watching an object that he would get from *being* that object. Would it not be grand to be a kite, would it not be masterful? Here we stand, slaves of the force of gravity, sometimes toying with it for a moment when we take a dive or a coast, at other times having to struggle against it for our very lives, and all the time bound and limited by it — while the kite soars aloft in apparent defiance of all such laws and limitations. Of course it fascinates us, since watching it gives us, by empathy, some of the sense of power and freedom that seems appropriate to the behavior of a kite. Perhaps the fascination of fire is empathy of a similar sort; for fire is power.

Having thus found the mastery impulse here, there and almost everywhere in the realm of play, we are tempted to assume a masterful attitude ourselves and say, "Look you! We have discovered the one and only play motive, which is none other than self-assertion." Thus we should be forgetting the importance in play of danger and the escape motive, the importance of manipulation for its own sake, and the importance of the mere joy of muscular and mental activity. Also, we should be overlooking the occasional presence of laughter, the occasional presence of sex attraction, and the almost universal presence of the gregarious and other social motives. Play has many motives, not merely a single one.

Play gives rise to situations that are interesting and attractive to the players, though the attraction cannot be traced to any of our "dependable motives." The rhythm of dancing, marching, and of children's sing-song games can scarcely be

traced to any of them. The sociability of games goes beyond mere gregariousness, since it calls for acting together and not simply for being together; and at the same time it goes beyond competition and self-assertion, as is seen in the satisfaction the players derive from good team work. It is true that the individual player does not lay aside his self-assertion in becoming a loyal member of a team; rather, he identifies himself with the team, and finds in competition with the opposing team an outlet for his mastery impulse. But at the same time it is obvious that self-assertion would be still more fully gratified by man-to-man contests; and therefore the usual preference of a group of people for team play shows the workings of some other motive than self-assertion. The fact seems to be that coördinated group activity is an independent source of satisfaction.

If the self-assertive impulse of an individual player is too strongly aroused, he spoils the game, just as an angry player spoils a friendly wrestling match or snowball fight, and just as a thoroughly frightened passenger spoils a trip down the rapids, which was meant to be simply thrilling. Though the emotions and fundamental motives of life are active in play, they must not be too active, for a game is a complex activity, carried on at a relatively high level, and furnishing its own interest and its own motivation, just as other human activities do. A motive, we remember, is an activity in progress, and any complex activity, once the individual is fully embarked upon it, furnishes its own motivation.[1]

DAYDREAMS

Daydreaming is a sort of play, more distinctly imaginative than most other play. Simply letting the mind run, as in the instances cited under free association, where A makes you think of B and B of C, and so on — this is not exactly day-

[1] See page 265.

dreaming, since there is no "dream," no castle in the air nor other construction, but simply a passing from one recalled fact to another. In imaginative daydreaming, facts are not simply recalled but are rearranged or built together into a story or "castle" or scheme. A daydream typically looks toward the future, as a plan for possible doing; only, it is not a serious plan for the future — which would be controlled imagination — nor necessarily a plan which could work in real life, but merely play of imagination. If we ask the same questions here as we did regarding child's play, we find again that it is easier to define the end-result and the source of satisfaction in daydreaming than it is to define the stimulus or the exact nature of the imaginative process.

Daydreams are motivated, as can be judged from the absorption of the dreamer in his dream, and also from an examination of the end-results of this kind of imagination. Daydreams usually have a *hero,* and that hero is usually the dreamer's self. Sometimes one is the conquering hero, and sometimes the suffering hero, but in both cases the recognized or unrecognized merit of oneself is the big fact in the story, so that the mastery motive is evidently finding satisfaction here as well as in other forms of play. Probably the conquering hero dream is the commoner and healthier variety. A classical example is that of the milkmaid who was carrying on her head a pail of milk she had been given. "I'll sell this milk for so much, and with the money buy a hen. The hen will lay so many eggs, worth so much, for which I will buy me a dress and cap. Then the young men will wish to dance with me, but I shall spurn them all with a toss of the head." Her dream at this point became so absorbing as to get hold of the motor system and call out the actual toss of the head — but we are not after the moral just now; we care simply for the dream as a very true sample of many, many daydreams. Such dreams are a means of getting for the moment the satisfaction of some

desire, without the trouble of real execution; and the desire gratified is very often some variety of self-assertion. Sometimes the hero is not the dreamer's self, but some one closely identified with himself. The mother is prone to make her son the hero of daydreams and so to gratify her pride in him.

The "suffering hero" daydream seems at first thought inexplicable, for why should any one picture himself as having a bad time, as misunderstood by his best friends, ill-treated by his family, jilted by his best girl, unsuccessful in his pet schemes? Why should any one make believe to be worse off than he is; what satisfaction can that be to him? Certainly, one would say, the mastery motive could not be active here. And yet — do we not hear children *boasting* of their misfortunes? "Pooh! That's only a little scratch; I've got a real deep cut." My cut being more important than your scratch makes me, for the moment, more important than you, and gives me a chance to boast over you. Older people are known sometimes to magnify their own ailments, with the apparent aim of enhancing their own importance. Perhaps the same sort of motive underlies the suffering hero daydream.

I am smarting, let us suppose, from a slight administered by my friend; my wounded self-assertion demands satisfaction. It was a very little slight, and I should make myself ridiculous if I showed my resentment. But in imagination I magnify the injury done me, and go on to picture a dreadful state of affairs, in which my friend has treated me very badly indeed, and perhaps deserted me. Then I should not be ridiculous, but so deeply wronged as to be an important person, one to be talked about; and thus my demand for importance and recognition is gratified by my daydream.

Usually the suffering hero pictures himself as in the right, and animated by the noblest intentions, though misunderstood, and thus further enhances his self-esteem; but sometimes he takes the other tack and pictures himself as wicked —

but as very, very wicked, a veritable desperado. It may be his self-esteem has been wounded by blame for some little meanness or disobedience of his own, and he restores it by imagining himself a great, big, important sinner instead of a small and ridiculous one. In adolescence, the individual's growing demand for independence is often balked by the continued domination of his elders, and he rebelliously plans quite a career of crime for himself. He'll show them! They won't be so pig-headedly complacent when they know they have driven him to the bad. You can tell by the looks of a person whose feelings are hurt that he is imagining something; usually he is imagining himself either a martyr or a desperado, or some other kind of suffering hero. The suffering hero daydream is a substitute for a fight or some other active self-assertion. The conquering hero daydream is often motivated in the same way; for example, our friend the milkmaid would not have been so ready to scorn the young men with a toss of the head if she had not been feeling her own actual inferiority and lack of fine clothes. The daydream makes good, in one way or another, for actual inability to get what we desire.

The desire which is gratified in the play of imagination belongs very often indeed under the general head of self-assertion; but when one is in love it is apt to belong under that head. Love dreams of the agreeable sort need no further motivation; but the unpleasant, jealous type of love dream is at the same time a suffering hero dream, and certainly involves wounded self-assertion along with the sexual impulse. Probably the self-asserting daydream is the commonest variety, take mankind as a whole, with the love dream next in order of frequency. But there are many other sorts. There is the humor daydream, illustrated by the young person who suddenly breaks into a laugh and when you ask why replies that she was thinking how funny it would be if, etc., etc. She is very fond of a good laugh, and not having anything laughable

actually at hand proceeds to imagine something. So, a music lover may mentally rehearse a piece when he has no actual music to enjoy; and if he has some power of musical invention, he may amuse himself, in idle moments, by making up music in his head; just as one who has some ability in decorative design may fill his idle moments by concocting new designs on paper. When vacation time approaches, it is hard for any one, student or professor, to keep the thoughts from dwelling on the good times ahead, and getting some advance satisfaction. Thus all kinds of desires are gratified in imagination.

WORRY

Do we have fear daydreams, as we have amusements utilizing the fear and escape motive? Yes, sometimes we imagine ourselves in danger and plan out an escape. One individual often amuses himself by imagining he is arrested and accused of some crime, and figuring out how he could establish an alibi or otherwise prove his innocence. But fear daydreams also include *worry,* which seems at first to be an altogether unpleasant state of mind, forced upon us and not indulged in as most daydreams are. Yet, as the worry is often entirely needless, it cannot be said to be forced upon a person, but must have some motive. There must be some satisfaction in it, in spite of all appearance.

Some abnormal cases of worry suggest the theory that the fear is but a cloak for unacknowledged desire. Take this extreme case. A young man, "tied to the apron-strings" of a too affectionate and too domineering mother, has a strong desire to break loose and be an independent unit in the world; but at the same time, being much attached to his mother, he is horrified by this desire. She goes on a railroad journey without him — just an ordinary journey with no special danger — but all the time she is away he is in an agony of suspense lest the train may be wrecked. Such an abnormal degree of worry

calls for explanation. Well — did not the worry perhaps conceal a wish, a wish that the train *might* be wrecked? So he would be set free without any painful effort on his part; and he was a young man who shrank from all effort. The psychopathologist who studied the case concluded that this was really the explanation of the worry.

If, however, we take such extreme cases as typical and cynically apply this conception to all worries, we shall make many mistakes. A student worries unnecessarily about an examination; therefore, he desires to fail. A mother worries because her child is late in getting home; therefore, she wants to be rid of that child. Thus, by being too psychopathological, we reach many absurd conclusions in everyday life; for it is the child that is loved that is worried over, and it is the examination that the student specially wishes to pass that he fears he has flunked.

Worry is a substitute for real action when no real action is possible. The student has done all he can do; he has prepared for the examination, and he has taken the examination; now there is nothing to do except wait; so that the rational course would be to dismiss the matter from his mind; if he cannot accomplish that, but must do something, then the only thing he can do is to speculate and worry. So also the mother, in her uncertainty regarding her child, is impelled to action, and if she knew of any real thing to do she would do it and not worry; but there is nothing to do, except in imagination. Worry is fundamentally due to the necessity of doing something with any matter that occupies our mind; it is an imaginative substitute for real action.

But worry may be something of an indoor sport as well. Consider this — if the mother really believed her child had fallen into the pond, she would rush to pull him out; but while she is worrying for fear he may have fallen in, she remains at home. Really she expects to see him come home any minute,

but by conjuring up imaginary dangers she is getting ready to make his home-coming a great relief instead of a mere humdrum matter. She is getting the thrill of danger with escape fully expected.

The normal time for a daydream is the time when there is no real act to be performed. A strong man uses it as the amusement of an idle moment and promptly forgets it. But one who is lacking in force, especially the personal force needed in dealing with other people, may take refuge in daydreams as a substitute for real doing. Instead of hustling for the money he needs he may, like Micawber, charm himself with imagining the good opportunities that may turn up. Instead of going and making love to the lady of his choice, he shyly keeps away from her and merely dreams of winning her. He substitutes imaginary situations for the real facts of his life, and gratifies his mastery motive by imaginary exploits. He invents imaginary ailments to excuse his lack of real deeds. He conjures up imaginary dangers to worry over. All this is abuse of imagination.

DREAMS

Let us turn now from daydreams to dreams of the night. These also are play of imagination, even freer from control and criticism than the daydream. In sleep the brain activity sinks to a low level, and perhaps ceases altogether in the deepest sleep. Most of the dreams that are coherent enough to be recalled probably occur just after we have gone to sleep or just before we wake up, or at other times when sleep is light. At such times the simpler and more practised functions, such as recall of images, can go on, though criticism, good judgment, reasoning, and all that sort of delicate and complex activity, do not occur. Daytime standards of probability, decorum, beauty, wit, and excellence of any sort are in abeyance; consistency is thrown to the winds, the scenes being shifted

in the middle of a speech, and a character who starts in as one person merging presently into somebody else. Dreams follow the definition of imagination or invention, in that materials recalled from different contexts are put together into combinations and rearrangements never before experienced. The combinations are often bizarre and incongruous.

Perhaps the most striking characteristic of dreams is their seeming reality while they last. They seem real in spite of their incongruity, because of the absence of critical ability during sleep. In waking life, when the sight of one object reminds me of another and calls up an image of that other, I know that the image is an image, and I know I have thought of two different things. In sleep the same recall by association occurs, but the image is forthwith accepted as real; and thus things from different sources get together in the same dream scene, and a character who reminds us of another person forthwith becomes that other person. We are not mentally active enough in sleep to hold our images apart. Associative recall, with blending of the recall material, and with entire absence of criticism, describes the process of dreaming.

What is the *stimulus*, to which the dream responds? Sometimes there is an actual sensory stimulus, like the alarm clock or a stomach ache; and in this case the dream comes under the definition of an illusion; it is a false perception, more grotesquely false than most illusions of the day. A boy wakes up one June morning from a dream of the Day of Judgment, with the last trump pealing forth and blinding radiance all about — only to find, when fully awake, that the sun is shining in his face and the brickyard whistle blowing the hour of four-thirty A.M. This was a false perception. More often, a dream resembles a daydream in being a *train of thoughts and images* without much relation to present sensory stimuli; and then the dream would come under the definition of hallucination instead of illusion.

Sometimes a sensory stimulus breaks in upon a dream that is in progress, and is interpreted in the light of this dream. In one experiment, the dreamer, who was an authoress, was in the midst of a dream in which she was discussing vacation plans with a party of friends, when the experimenter disturbed her by declaiming a poem; in her dream this took the form of a messenger from her publisher, reciting something about a contract which seemed a little disturbing but which she hoped (in the dream) would not interfere with her vacation. Maury, an early student of this topic, was awakened from a feverish dream of the French Revolution by something falling on his neck; this, under the circumstances of his dream, he took to be the guillotine.

Now, *why* is a dream? What satisfaction does it bring to the dreamer? Or shall we say that it is merely a mechanical play of association, with no motivation in it? Dreams are interesting while they last, sometimes fearful, sometimes angry, sometimes amorous, otherwise not very emotional but distinctly interesting, so that many people hate to have a dream broken up by awaking. It seems likely, then, that dreams are like daydreams in affording gratification to desires. They are "wish-fulfilling," to borrow a term from Freud's theory of dreams, soon to be considered.

A boy dreams repeatedly of finding whole barrels of assorted jackknives, and is bitterly disappointed every time to awake and find the knives gone; so that finally he questions the reality of the dream, but pinching himself (in the dream) concludes he must be awake this time. An adult frequently dreams of finding money, first a nickel in the dust, and then a quarter close by, and then more and more, till he wakes up and spoils it all. Such dreams are obviously wish-fulfilling, as are also the sex dreams of sexually abstinent persons, or the feasting dreams of starving persons, or the polar explorer's recurring dream of warm, green fields. An eminent psy-

chologist has given a good account of a dream which he had while riding in an overcrowded compartment of a European train, with the window closed and himself wedged in tightly far from the window. In this uncomfortable situation he dropped asleep and dreamed that he had a seat next to the window, had the window open and was looking out at a beautiful landscape. In all these cases *the wish gratified in the dream is one that has been left unsatisfied in the daytime,* and this is according to the famous passage, slightly paraphrased, "What a man hath, why doth he yet dream about?" The newly married couple do not dream of each other. We seldom dream of our regular work, unless for some reason we are disturbed over it. The desires that are satisfied during the day do not demand satisfaction in dreams; but any desire that is aroused during the day without being able to reach its conclusion is likely to come to the surface in a dream.

The mastery motive, so prominent in daydreams, can be detected also in many sleep dreams. There are dreams in which we do big things — tell excruciatingly funny jokes, which turn out when recalled next day to be utterly flat; or improvise the most beautiful music, which we never can recall with any precision, but which probably amounted to nothing; or play the best sort of baseball. The gliding or flying dream, which many people have had, reminds us of the numerous toys and sports in which defiance of gravity is the motive; and certainly it gives you a sense of power and freedom to be able, in a dream, to glide gracefully up a flight of stairs, or step with ease from the street upon the second-story balcony. One dream which at first thought cannot be wish-fulfilling perhaps belongs under the mastery motive: The dreamer sees people scurrying to cover, looks up and sees a thunderstorm impending; immediately he is struck by lightning and knocked down in the street; but he finds he can rise and walk home, and seems to have suffered no harm except for a black blotch around

one eye. Now, any man who could take lightning that way would be proud to wear the scar. So the dream was wish-fulfilling, and the wish involved was, as often, the self-assertive impulse.

This last dream is a good one, however, for pointing another moral. We need not suppose that the dreamer was aiming at the dénouement from the beginning of the dream. Dreams have no plot in most instances; they just drift along, as one thing suggests another. The sight of people running to cover suggested a thunderstorm, and that suggested that "I might get struck," as it would in the daytime. Now, the dream mentality, being short on criticism, has no firm hold on "may be" and "might be," but slides directly into the present indicative. The thought of being struck is *being* struck, in a dream. So we need not suppose that the dreamer pictured himself as struck by lightning in order to have the satisfaction of coming off whole and bragging of the exploit. In large measure the course of a dream is determined by free association; but the mastery motive and other easily awakened desires act as a sort of bias, facilitating certain outcomes and inhibiting others.

But there are unpleasant dreams, as well as pleasant. There are fear dreams, as well as wish dreams. A child who is afraid of snakes and constantly on the alert against them when out in the fields during the day, dreams repeatedly of encountering a mass of snakes and is very much frightened in his sleep. Another child dreams of wolves or tigers. A person who has been guilty of an act from which bad consequences are possible, dreams that those consequences are realized. The officer suffering from nervous war strain, or "shell shock," often had nightmares in which he was attacked and worsted by the enemy.

A large share of dreams does not fit easily into any of the classes already described. They seem too fantastic to have any

personal meaning. Yet they are interesting to the dreamer, and they would be worth going to see if they could be reproduced and put on the stage. Isn't that sufficient excuse for them? May they not be simply a free play of imagination that gives interesting results just because of its freedom and vividness?

FREUD'S THEORY OF DREAMS

Just at this point we part company with Freud, whose ideas on dreams as wish-fulfilments we have been following in the main. Not that Freud would O K our account of dreams up to this point. Far from it. It would seem to him on too superficial a level altogether, dealing as it does with conscious wishes and with straightforward fulfilments. It has left out of account the "Unconscious" and its symbolisms. The Freudian would shake his head at our interpretation of the lightning dream, and say, "Oh, there is a good deal more in that dream. We should have to analyze that dream, by letting the dreamer dwell on each item of it and asking himself what of real personal significance the stroke of lightning or the scar around the eye suggested to him. He would never be able by his unaided efforts to find the unconscious wishes fulfilled in the dream, but under the guidance of the psychoanalyst, who is a specialist in all matters pertaining to the Unconscious, he may be brought to realize that his dream is the symbolic expression of wishes that are unconscious because they have been suppressed."

The Unconscious, according to Freud, consists of forbidden wishes — wishes forbidden by the "censor," which represents the moral and social standards of the individual and his critical judgment generally. When the censor suppresses a wish, it does not peaceably leave the system, but sinks to an unconscious state in which it is still active and liable to make itself felt in ways that get by the censor because they are disguised and symbolic. An abnormal worry is such a disguise, a queer

idea that haunts the nervous person is another, "hysterical" paralysis or blindness is another.

In normal individuals the dream life is held by Freud to be the chief outlet for the suppressed wishes; for then the censor sleeps and "the mice can play." Even so, they dare not show themselves in their true shape and color, but disguise themselves in innocent-appearing symbolism. That lightning may stand for something much more personal. Let your mind play about that "being knocked down by lightning and getting up again," and ask yourself what experience of childhood it calls up. — Well, I remember the last time my father whipped me and I came through defiant, without breaking down as I always had before on similar occasions. — Yes, now we are on the track of something. The lightning symbolizes your father and his authority over you, which as a child you resented. You were specially resentful at your father's hold on your mother, whom you regarded as yours, your father being a rival with an unfair advantage. Your sex impulse was directed toward your mother, when you were a mere baby, but you soon came to see (how, Freud has never clearly explained) that this was forbidden, and that your father stood in the way. You resented this, you hated your father, while you loved him, too; so this whole complex and troublesome business was suppressed to the Unconscious, whence it bobs up every night in disguise.

Freud has claimed the dream as his special booty, and insists that all dreams are wish-fulfilments, even those that seem mere fantastic play of imagination, since, as he sees it, no mental activity could occur except to gratify some wish. Further, he holds, most if not all dreams are fulfilments of suppressed wishes, and these are either sex or spite wishes, the spite wishes growing out of the interference of other people with our sex wishes.

The objection to Freud's theory of dreams is, first, that he

fails to see how easy-running the association or recall mechanism is. It isn't necessary to look for big, mysterious driving forces, when we know that A makes you think of B, and B of C, with the greatest ease. The dreamer isn't laboring, he is idly playing, and his images come largely by free association, with personal desires giving some steer.

Another objection is that Freud overdoes the Unconscious; suppressed wishes are usually not so unconscious as he describes them; they are unavowed, unnamed, unanalyzed, but conscious for all that. It is not so much the unconscious wish that finds outlet in dreams and daydreams, as the unsatisfied wish, which may be perfectly conscious.

Another very serious objection to Freud is that he overdoes the sex motive or "libido." He says there are two main tendencies, that of self-preservation and that of reproduction, but that the former is ordinarily not much subject to suppression, while the latter is very much under the social ban. Consequently the Unconscious consists mostly of suppressed sex wishes. Evidently, however, Freud's analysis of human motives is very incomplete. He does not clearly recognize the self-assertive tendency, which, as a matter of fact, is subjected to much suppression from early childhood all through life, and which undoubtedly has as much to do with dreams, as it has with daydreams. Freud has given an "impressionistic" picture, very stimulating and provocative of further exploration, but by no means to be accepted as a true and complete map of the region.

AUTISTIC THINKING

Dreaming, whether awake or asleep, is free imagination. It does not have to check up with any standard. So long as it is interesting and gratifies the dreamer, it serves its purpose. Sometimes the daydreamer exercises some control, breaking off a spiteful or amorous dream because he thinks it had better

not be indulged; but in this he ceases to be simply a daydreamer. Daydreaming, by itself, is an example of what is called "autistic thinking," which means thinking that is sufficient unto itself, and not subjected to any criticism. Autistic thinking gratifies some desire and that is enough for it. It does not submit to criticism from other persons nor from the individual himself, nor does it seek to square itself with the real world.

Autistic thinking, indulged in by every imaginative person in moments of relaxation, is carried to an absurd extreme by some types of insane individuals. One type withdraws so completely from reality as to be inaccessible in conversation, unresponsive to anything that happens, entirely immersed in inner imaginings. Others, while living in the world about them, transform it into a make-believe world by attaching meanings to things and persons as suits themselves. This institution, in which the subject is confined, is his royal palace, the doctors are his officials, the nurses his wives, "thousands of them, the most beautiful women in creation." Or the delusion may take the line of the suffering hero, the subject imagining himself a great man shut up in this place by the machinations of his enemies; the doctors are spies and enemy agents, and the nurses also act suspiciously; his food is poisoned, and he is kept in a weak and helpless condition, all out of fear of him. It is impossible to argue the patient out of his delusions by pointing out to him how clearly they conflict with reality; he evades any such test by some counter-argument, no matter how flimsy, and sticks to his dream or make-believe.

Autistic thinking is contrasted with realistic thinking, which seeks to check up with real facts; it may be contrasted also with socialized thinking, which submits to the criticism of other people; and it may even be contrasted with self-criticized thinking, in which the individual scrutinizes what he has imagined, to see whether it is on the whole satisfactory to

himself, or whether it simply gratified a momentary impulse and ran counter to more permanent desires.

INVENTION AND CRITICISM

"Criticism" — the word has been used repeatedly, and it is time it gave an account of itself. Criticism is check-up. One desire gets criticized by running afoul of another desire, one idea by conflicting with another idea. We concoct a fine joke to play on our friend; but then the thought comes to us that he may not take it kindly; we don't want to break with our friend, and so we regretfully throw our promising invention on the scrap heap. That is self-criticism, the balancing off of one impulse by another. Self-criticism is obnoxious to the natural man, who prefers to follow out each desire till it reaches its goal; but he learns self-criticism in the hard school of experience. For plenty of criticism is directed upon the individual from without — from the environmental check-up.[2]

Criticism is directed upon him by the facts of the real world, so soon as he tries to act out what he has imagined. Often his invention will not work, his plan does not succeed, and he must cast it away and think up a new one. At this point the "weak brother" is tempted to give up trying, and take refuge in autistic thinking, but the stronger individual accepts the challenge of reality. He sees that an invention is not satisfactory unless it will work, and sets about learning what will work and what will not, so accumulating observations that later enable him to criticise his own ideas, to some extent, before trying them out on real things.

Criticism is directed upon the individual from the side of other people, who, from the day he first begins to tell his childish imaginings, are quite free with their objections. Humiliated by this critical reception of his ideas, the individual may resolve to keep them to himself for the future, and

[2] See page 167.

draw away, again, towards autistic thinking; or, more forcefully, he may exert himself to find some idea that will command the approval of other people. If he can take rebuffs good-naturedly, he soon finds social criticism a great help, and two heads better than one in planning any invention that needs to work. He accumulates knowledge of what will pass muster when presented to other people, and thus again learns self-criticism.

Self-criticism is helped by such rules as to " think twice," to " sleep on it before deciding," to " drop the matter for a time and come back to it and see whether it still looks the same." When you are all warmed up over an idea, its recency value gives it such an advantage over opposing ideas that they have no chance, for the moment, of making themselves felt in the line of criticism.

I once heard the great psychologist, and great writer, William James, make a remark that threw some light on his mode of writing. In the evening, he said, after warming up to his subject, he would write on and on till he had exhausted the lead he was following, and lay the paper aside with the feeling, "Good! Good! That's good." The next morning, he said, it might not seem good at all. This calls to mind the old advice to writers about its being " better to compose with fury and correct with phlegm than to compose with phlegm and correct with fury." The phlegmatic critical attitude interferes considerably with the enthusiastic inventive activity. Give invention free rein for the time being, and come around with criticism later.

Some over-cautious and too self-critical persons, though rather fertile in ideas, never accomplish much in the way of invention because they cannot let themselves go. Criticism is always at their elbow, suggesting doubts and alternatives and preventing progress in the creative activity, instead of biding its time and coming in to inspect the completed result.

For a similar reason, much of the best inventive work — writing, for example, or painting — is done in prolonged periods of intense activity, which allow time for invention to get warmed to its task, when it takes the bit in its teeth and dashes off at a furious speed, leaving criticism to trail along behind.

Invention in the service of art or of economic and social needs is controlled imagination, realistic, socialized, subjected to criticism. It cannot afford to be autistic, but must meet objective or social standards. Mechanical inventions must work when translated into matter-of-fact wood and iron, and must also pass the social test of being of some use. Social inventions of the order of institutions, laws, political platforms and slogans, plans of campaign, must work in the sense of bringing the desired response from the public. Social imagination of the very important sort suggested by the proverbs, "Seeing ourselves as others see us," or "Putting ourself in the other fellow's place" — for it is only by imagination that we can thus get outside of our own experience and assume another point of view — must check up with the real sentiments of other people.

THE ENJOYMENT OF IMAGINATIVE ART

It requires imagination to enjoy art as well as to produce it. The producer of the work of art puts the stimuli before you, but you must make the response yourself, and it is an inventive response, not a mere repetition of some response you have often made. The novelist describes a character for you, and you must respond by putting together the items in the description so as to conceive of a character you have never met. The painter groups his figures before you, but you must get the point of the picture for yourself. The musical composer provides a series of chords, but you must get the "hang" of the passage for yourself, and if he has introduced a novel effect,

it may not be easy to find any beauty in it, at least on the first hearing.

Art, from the consumer's side, is play. It is play of the imagination, with the materials conveniently presented by the artist. Now, as art is intended to appeal to a consumer (or enjoyer), the question as to sources of satisfaction in the enjoyment of art is fundamental in the whole psychology of art, production as well as consumption.

We have the same questions to ask regarding the enjoyment of a *novel* as regarding a daydream. Novel-reading is daydreaming with the materials provided by the author, and gratifies the same motives. A novel to be really popular must have a genuine hero or heroine — some one with whom the reader can identify himself. The frequency of novels in which the hero or heroine is a person of high rank, or wins rank or wealth in the course of the story, is a sign of appeal to the mastery motive. The humble reader is tickled in his own self-esteem by identifying himself for the time with the highborn or noble or beautiful character in the story. The escape motive also is relied upon to furnish the excitement of the story, which always brings the hero into danger or difficulty and finally rescues him, much to the reader's relief. Love stories appeal, of course, to the sex impulse, humorous stories to laughter, and mystery stories to curiosity. Cynical stories, showing the "pillars of society" in an ignoble light, appeal to the self-assertive impulse of the reader, in that he is led to apply their teaching to pretentious people whom he knows about, and set them down a peg, to his own relative advancement. But here again we have to insist, as under the head of sports and daydreams, that interests of a more objective kind also are gratified by a good work of fiction. A story that runs its logical course to a tragic end is interesting as a good piece of workmanship, and as an insight into the world. We cannot heartily identify ourselves with Hamlet or Othello, yet we should be sorry to have

those figures erased from our memories; they mean something, they epitomize world facts that compel our attention.

The appeal of art is partly emotional. A great work of art, the Apollo Belvedere or the Sistine Madonna, when you suddenly come upon it in walking through a gallery, may move you almost to tears. Beautiful music, and not necessarily sad music either, has the same effect. Why this particular emotion should be aroused is certainly an enigma. "Crying because you are so happy" is similar but itself rather inexplicable. In many other cases, the emotional appeal of art is easily analyzed.

Art makes also an intellectual appeal. It is satisfying partly because of this appeal, as is clear when we remember that many great works of art require mental effort in order to grasp and appreciate them. You must be wide-awake to follow a play of Shakespeare; you must puzzle out the meaning of a group painting before fully enjoying it; you must study some of the detail of a Gothic cathedral before getting the full effect; music may be too "classical" for many to grasp and follow. Unless, then, the artist has made a great mistake, the mental activity which he demands from his public must contribute to the satisfaction they derive from his works. If his appeal were simply to their emotions, any intellectual labor would be a disturbing element. The intellectual appeal is partly to objective interests in the thing presented, partly to interest in the workmanship, and partly to the mastery motive in the form of problem solution.

Perhaps we do not often think of a fine painting or piece of music as a problem set us for solution, but it is that, and owes part of its appeal to its being a problem. To "get the hang of" a work of art requires some effort and attention; if the problem presented is too difficult for us, the work of art is dry; if too easy, it is tame.

The mastery motive is probably as important in the enjoyment of art as it is in play and dreaming. It comes in

once in the joy of mastering the significance of the work of art, and again in self-identification with the fine characters portrayed.

Empathy in art enjoyment. At first thought, some forms of art, as architecture, seem incapable of making the just mentioned double appeal to the mastery motive. Architecture can certainly present problems for the beholder to solve, but how can the beholder possibly identify himself with a tower or arch? If, however, we remember the "empathy" that we spoke of under the head of play, we see that the beholder may project himself into the object, unintentionally of course, and thus perhaps get satisfaction of his mastery impulse.

Look at a pillar, for example. If the pillar is too massive for the load supported, it gives you the unsatisfactory impression of doing something absurdly small for your powers. If on the contrary the pillar is too slender for the load that seems to rest upon it, you get the feeling of strain and insecurity; but if it is rightly proportioned, you get the feeling of a worthy task successfully accomplished. The pillar, according to empathy, pleases you by arousing and gratifying your mastery impulse; and many other architectural effects can be interpreted in the same way.

Empathy can perhaps explain the appeal of the *big* in art and nature. In spite of the warnings put forth against thinking of mere bigness as great or fine, we must admit that size makes a very strong appeal to something in human nature. The most perfect miniature model of a cathedral, however interesting and attractive as it rests on the table before you, fails to make anything like the impression that is made by the giant building towering above you. Big trees, lofty cliffs, grand canyons, tremendous waterfalls, huge banks of clouds, the illimitable expanse of the sea, demonstrate cogently the strong appeal of the big. Perhaps the big is not necessarily grand, but the grand or sublime must be big or somehow suggest

bigness. The question is, then, what it is in us that responds to the appeal of the big.

Perhaps a submissive attitude is aroused. This great mountain, so far outclassing me that I am not tempted in the least to compete with it, affords me the joy of willing submission. The escape motive may come in along with submissiveness — at the first sight of the mountain a thrill of fear passes over me, but I soon realize that the mountain will not hurt me in spite of its awe-inspiring vastness; so that my emotion is blended of the thrill of fear, the relief of escape, and the humble joy of submission. That is one analysis of the esthetic effect of bigness.

Empathy suggests a very different analysis. According to this, projecting myself into the mountain, identifying myself with it, I experience the sensation of how it feels to be a mountain. It feels big — I feel big. My mastery impulse is gratified. To decide between these two opposing interpretations ought to be possible from the behavior or introspection of a person in the presence of some big object. If he feels insignificant and humble and bows reverently before the object, we may conclude that a submissive attitude is aroused; but if the sight of the grand object makes him feel strong and fine, if he throws out his chest and a gleam comes into his eye, then everything looks like the mastery motive. Quite possibly, the effect varies with the person and the occasion.

We have to think of art as a great system or collection of inventions that owes its existence to its appeal to human nature, and that has found ways, as its history has progressed, of making its appeal more and more varied. Art is a type in these respects of many social enterprises, such as sport, amusement, and even such serious matters as politics and industry. Each of these is a collection of inventions that persists because it appeals to human impulses, and each one appeals to a variety of different impulses.

THE PSYCHOLOGY OF INVENTIVE PRODUCTION

To the consumer, art is play, but to the producer it is work, in the sense that it is directed toward definite ends and has to stand criticism according as it does or does not reach those ends. What is true of the producer of art works is true also of other inventors, and we may as well consider all sorts of controlled imagination together.

In spite of the element of control that is present in productive invention, the really gifted inventor seems to make play of his work to a large extent. Certainly the inventive genius does not always have his eyes fixed on the financial goal, nor on the appeal which his inventions are to make to the public. It is astonishing to read in the lives of inventors what a lot of comparatively useless contrivances they busied themselves with, apparently from the pure joy of inventing. One prolific writer said that he "never worked in his life, only played." The inventor likes to manipulate his materials, and this playfulness has something to do with his originality, by helping to keep him out of the rut.

That "necessity is the mother of invention" is only half of the truth; it points to the importance of a directive tendency, but fails to show how the inventor manages to leave the beaten path and really invent. Necessity, or some desire, puts a question, without which the inventor would not be likely to find the answer; but he needs a kind of flexibility or playfulness, just because his job is that of seeing things in a new light. We must allow him to toy with his materials a bit, and even to be a bit "temperamental," and not expect him to grind out works of art or other inventions as columns of figures are added.

When inventive geniuses have been requested to indicate their method, they have been able to give only vague hints. How does the musical composer, for example, free himself of

all the familiar pieces and bring the notes into a fresh arrangement? All that he can tell about it is usually that he had an "inspiration"; the new air simply came to him. Now, of course the air did not really come to him from outside; he made it, it was his reaction, but it was a quick, free reaction, of which he could observe little introspectively.

Perhaps the best-studied case of invention is that of the learner in typewriting, who, after laboriously perfecting his "letter habits" or responses to single letters by appropriate finger movements on the keyboard, may suddenly find himself writing in a new way, the word no longer being spelled out, but being written as a unit by a coördinated series of finger movements. The amazing thing is that, without trying for anything of the kind, he has been able to break away from his habit of spelling out the word, and shift suddenly to a new manner of writing. He testifies that he did not plan out this change, but was surprised to find himself writing in the new way. He was feeling well that day, hopeful and ambitious, he was striving for greater speed, and, while he was completely absorbed in his writing, this new mode of reaction originated.

We see in this experimentally studied case some of the conditions that favor invention. Good physical condition, freshness, mastery of the subject, striving for some result, and "hopefulness." Now, what is that last? Confidence, enterprise, willingness to "take a chance," eagerness for action, and readiness to break away from routine? Some of this independent, manipulating spirit was probably there.

A soldier, so wounded as to paralyze his legs but capable of recovery by training, had advanced far enough to hobble about with a cane and by holding to the walls. One morning, feeling fit, he took a chance and left the wall, cutting straight across the room; and getting through without a fall, was naturally much encouraged and maintained this advance. This might be called invention; it was breaking away from what

had become routine, and that is the essential fact about the inventive reaction. This playful spirit of cutting loose, manipulating, and rearranging things to suit yourself is certainly a condition favorable to invention. It does not guarantee a valuable invention, but it at least helps towards whatever invention the individual's other qualifications make possible.

IMAGINATION CONSIDERED IN GENERAL

Finally, we must return to the question of definition or general description that was left open near the beginning of the chapter. There seem to be two steps in the inventive response, one preliminary, the other strictly inventive. The preliminary step brings the stimuli to bear, and invention is the response that follows.

Typically, the preliminary stage consists in recall and brings together materials from different past experiences. Facts recalled from different contexts are brought together, and invention consists in a response to such novel combinations of facts. The two steps in invention are, first, getting a combination of stimuli, and second, responding to the combination.

Sometimes it has been said that imagination consists in putting together material from different sources, but this leaves the matter in mid-air; recall can bring together facts from different sources and so afford the stimulus for an imaginative response, but the response goes beyond the mere togetherness of the stimuli. Thinking of a man and also of a horse is not inventing a centaur; there is a big jump from the juxtaposition of the data to the specific arrangement that imagination gives them. The man plus the horse may give no response at all, or may give many other responses besides that of a centaur; for example, a picture of the man and the horse politely bowing to each other. The particular manipulation, or imaginative response, that is made varies widely; sometimes it consists in taking things apart rather than putting them together, as

when you imagine how a house would look with the evergreen tree beside it cut down; always it consists in putting the data into new relationships, into new patterns.

Imagination thus presents a close parallel to reasoning, where, also, there are two stages, the preliminary consisting in getting the premises together and the final consisting in seeing the conclusion. The final response in imagination is in general like that in reasoning; both are *perceptive reactions;* but imagination is freer and more variable. Reasoning is governed by a very precise aim, to see the actual meaning of the combined premises; that is, it is exploratory; while imagination, though it is usually more or less steered either by a definite aim or by some bias in the direction of agreeable results, has after all much more latitude. It is seeking, not a relationship that is there, but one that can be put there.

EXERCISES

1. Show that make-believe can be used as an aid in serious thinking — "let this stand for so-and-so," etc.

2. A certain student was described as very intelligent, "because she will entertain any idea and play with it for a time." How does this remark suggest a connection between intelligence and imagination?

3. Show a connection between purpose and imagination.

4. Autistic thinking indulged in by a person who is offended at another.

5. Why do we need story writers — why would it not be enough to have a stenographic report of the sayings and doings of a person during a week's time?

6. What is meant by "composition" in painting, and what has it to do with imagination and with criticism?

7. Analysis of a dream. Take some dream that you recall well, and let your thoughts play about it, and about the separate items of it — about each object, person, speech, and happening in the dream

— with the object of finding what they remind you of that has personal significance for you. Let your thoughts run on, from each item as a starting point, but always with this quest for personal significance uppermost. When you have found matter of personal significance, put it together, and let your thoughts play about the combination, to see whether you find out anything about yourself. To be sure, the psychoanalyst would object that the individual cannot adequately analyze his own dreams, but the exercise is interesting and sometimes useful.

8. Problems in invention. Solve some of these, and compare the mental process with that of reasoning.

(a) Devise a game to be played by children and adults together, to everybody's satisfaction.

(b) Complete the following verses, not necessarily rhyming them:

"Too soon the village bells..............
And all too soon................
Along the path................
Round................"

(c) Imagine a weird creature, after the analogy of the centaur or the dragon.

(d) An accident with a happy ending.

(e) Outline for a talk on "emotion and imagination."

(f) Design the layout of a large piece of land, with a small lake on it, to be used as a site for a high school, with a playground, a park, and parking space for cars.

9. Show that inventiveness requires knowledge and something besides.

10. How does imagination come into play in scientific investigation?

REFERENCES

On dreams and daydreams, as they appear to students of abnormal psychology, see the comprehensive books by J. B. Morgan, *The Psychology of Abnormal People,* 1928, pp. 394–429; and by W. McDougall, *Outlines of Abnormal Psychology,* 1926, pp. 137–214.

For studies of invention and creative imagination, see F. W. Taussig, *Inventors and Money-Makers*, 1915; J. E. Downey, *Creative Imagination*, 1929, which considers especially the psychology of literature; and E. D. Hutchinson, *The Technique of Creative Thought*, 1929.

CHAPTER XII

PHYSIOLOGICAL PSYCHOLOGY

HOW THE NERVOUS SYSTEM AND OTHER ORGANS CARRY ON THE ACTIVITIES OF THE ORGANISM

Up to this point in our story, we have adhered pretty closely to our original intention of saving physiological analysis till near the close. We were forced into some exceptions in studying emotion and sensation, but on the whole we have described the activities of the organism as a whole, without asking about the organs and cells that carry on these activities. It is true, however, that any activity of the whole organism is at the same time an activity of organs and of cells, and needs to be so described in order to be thoroughly understood. Our psychology should be supplemented by at least a little physiology. We shall say almost nothing about the muscles, though they are certainly important enough in behavior. We shall say a little of the endocrine glands, which have awakened much interest of late. We shall say more of the nervous system, which has most to do with integrating the various organs into a whole individual and giving shape to his activities.

THE ENDOCRINE GLANDS AND THE CIRCULATION

The blood, as well as the nerves, connects every part of the organism with every other part and is an integrating agency. The circulation is a transportation system, carrying substances; the nervous system is like the telegraph and telephone, carrying messages or stimuli. But neither the circula-

tory nor the nervous system is much like a man-made system. The transportation of substances proceeds in this way: each organ pours its products into the blood, and the blood is circulated indiscriminately to all the organs, each of which helps itself out of the blood. The muscles, when active, help themselves to fuel substances, especially sugar, and to oxygen, and produce and throw into the blood carbon dioxide and other waste products. The liver, receiving the blood directly from the intestines, helps itself to food substances that have just been absorbed from the food, especially to the sugar, and stores them up; but when the muscles, being active, are withdrawing sugar from the blood and leaving it poor in sugar, this impoverished blood, circulating through the liver, sucks out some of the stored sugar and goes on its way replenished. The lungs, besides supplying oxygen to the blood, suck out the carbon dioxide and pass it out into the air. The kidneys suck nitrogenous wastes from the blood, and the intestine also removes certain wastes from the blood. The food tarrying in the large intestine is subjected to decomposition by bacteria, and some products of their action, mildly poisonous, are absorbed into the blood and carried around with all the rest. The blood contains water, salts, protein, fat and sugar, vitamins taken in with the food, any drugs or poisons that may have been taken, oxygen from the lungs, and many substances produced in the body, waste products, endogenous poisons, and hormones. The circulation is surprisingly rapid; it may take only fifteen seconds for a substance poured into the blood stream by one organ to reach all the other organs. Thus the circulation is decidedly an integrating agency, and the condition and activity of any organ, such as the muscles or the brain, is dependent on the substances that are being delivered into the blood stream by the other organs.

Hormones are substances produced, in very minute quantities, by the endocrine glands, and having potency to raise or

depress the activity of various organs.[1] An endocrine gland, or gland of internal secretion, is one that delivers its product to the blood. Take the pancreas for example. It produces two secretions: one, the pancreatic juice, is delivered into the intestine, where it acts upon the food present and takes an important part in digestion; but this is not called an internal

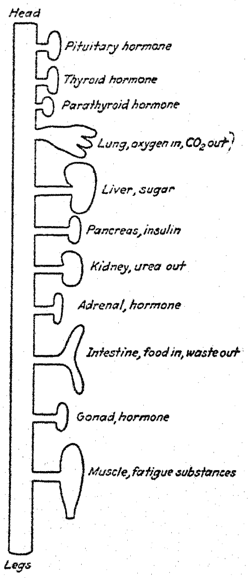


FIG. 60. — Diagrammatic view of the blood stream, with the various organs that contribute substances to it.

secretion, because it does not go into the blood stream. The other product of the pancreas is *insulin,* a hormone which enables the muscles to perform their remarkable feat of burning or oxidizing sugar and so obtaining energy. Without insulin, the organism gets into the condition of diabetes, in which sugar cannot be burned in the muscles, but accumulates in the blood, whence it is removed by the kidneys. Variations in the amount

[1] See also page 296.

of insulin in the blood cause variations in the activity of the individual, and in his sense of well-being. An excess of insulin makes the subject feel hungry, fatigued, tremulous and anxious; and a greater excess produces severe mental distress, delirium or even unconsciousness. The mental condition is also much affected in the diabetes that results from a deficiency of insulin.

Some endocrine glands important in behavior. Hormones affect primarily the development of the organism and the efficiency of the various organs, but secondarily any hormone is likely to have an effect on behavior also, as we have just seen in the case of insulin. Certain hormones affect the development and activity of the brain.

The *adrenals,* and the effect of their hormone in promoting muscular activity and in producing the organic state found in fear and anger, have already been described.[2]

The *gonads,* or primary sex organs, female ovary and male testis, besides the germinal tissue that gives rise to the ova and spermatozoa, contain *interstitial tissue* that produces hormones with important effects on growth and behavior. The male hormone steers development in the direction of masculinity, the female hormone in the direction of femininity, and they give rise at puberty to such "secondary" sex characteristics as the deep voice of men and the mammary glands of women. Both sex feeling, as already pointed out,[3] and the special sex functions such as menstruation and lactation, depend partly on these hormones. During pregnancy, a special hormone, produced in the active uterus, in connection with the growing child, stimulates the mother's mammary glands to further development, while at the same time inhibiting the actual formation of the milk; at birth the cessation of this hormone permits lactation to start. The sex hormones also stimulate general

[2] See page 296.
[3] See page 249.

activity of the organism, though their influence in this respect is less than that of hunger.

The *thyroid* gland in the neck gives out a hormone of special interest, chemically, because it contains the rather rare chemical element, iodine. Iodine is present in sea water, rather abundantly, and in smaller quantities in the spring and soil water of most regions, but in some mountain districts and in some other regions far from the sea — for example in Switzerland, in the Himalayas, and in the Great Lakes region and parts of the Northwest of the United States — there is practically no iodine present for the thyroid to use. The thyroid then enlarges — as if in the effort to do its utmost — and shows in the neck of many persons as a "goiter," but still it cannot supply the hormone in the absence of iodine. Some children are born with defective thyroids, and as a result do not develop normally. They remain dwarfs, "cretins," with poor brain development, sluggish in action and low in intelligence. If the thyroid becomes diseased in an otherwise normal adult, he becomes sluggish in action and thought; but this stupid condition disappears as if by magic as soon as, and as long as, he receives the hormones extracted from the thyroid glands of animals. There are also conditions in which the thyroid produces too much of the hormone, with the result that the individual is over-active and over-excitable, with excessive heart beat and high blood pressure, and a tendency to insomnia and, from time to time, to feverish hallucinations.

The primary effect of the thyroid hormone is to speed up metabolism, the chemical activity of the organism. In the absence of the hormone, metabolism sinks to a low level, both the "basal metabolism" that always occurs during inactivity and the extra metabolism of muscular activity. Little oxygen is consumed by the organism, and little carbon dioxide produced, in the absence of the thyroid hormone. As soon as the hormone is supplied, metabolism increases, and if there is too

much of the hormone, the metabolism is excessive. Probably the effects of the thyroid hormone on growth and on behavior are secondary results of this primary influence on metabolism.

The *parathyroids* are four or more small but important glands lying close to the thyroid. In a general way, their hormone acts counter to the thyroid hormone. More exactly, the parathyroid hormone enables the organism to utilize the calcium which is usually abundant in water and food, and which is needed for the bones and in many other ways. One effect of calcium is to lower the excitability of the tissues, especially of the muscles. If there is too much parathyroid hormone in the blood, the blood takes up too much calcium, and so lowers the activity of the muscles, even to paralysis in the extreme case. If there is too little of the parathyroid hormone, the blood is deficient in calcium, and the muscles become over-excitable — a condition sometimes seen in children and called "tetany." We may say that, as the thyroid mobilizes iodine and stimulates metabolism, so the parathyroid mobilizes calcium and prevents over-excitability. A proper balance of the two is important for well-being and efficiency.

The *pituitary* gland is another small but essential organ. It is attached to the base of the brain, inside the skull, in a very protected position, and it is necessary for life in obscure ways not thoroughly understood. The pituitary is somewhat like the thyroid in its affects, though neither organ can take the place of the other in the life of the organism. Both stimulate metabolism, and both are required for normal growth and development. Pituitary deficiency, if occurring before adolescence, keeps the individual short and delays or prevents sex development; at any age, such deficiency tends towards excessive fat, with low metabolism and general sluggishness. More striking results follow excess of the pituitary hormone; if this occurs during the growing period, it hastens and exaggerates growth, and sometimes produces giants eight feet

tall; if it occurs later, it causes over-development of the hands, feet and face — the condition known as "acromegaly."

The interdependence of the several endocrine glands is an important point to consider. They act with each other, and upon each other. With regard to growth, we have seen the importance of the pituitary, of the thyroid, and of the gonads; and with regard to metabolism, we find these three, and also the adrenals and insulin playing a part. For perfect health and efficiency, it is important to have a proper *balance* of the various hormones. If the thyroid is not adequately balanced by the parathyroid, we may have an over-active, restless individual; while if the parathyroid over-balances the thyroid, we may have an individual who is really too calm. Such considerations applied to the study of personalities are fascinating but rather speculative as yet.[4]

SENSE ORGANS AND MOTOR ORGANS

The individual "sees"; but when we examine the process of seeing in detail, we find activities of the lens, of the retina, of the optic nerve leading from the retina to the brain, and of the brain itself. The most important fact about the eye is that it is connected by its nerve with the brain; with this connection, even a very poor eye is of some use, but without such connection, the eye would play no possible part in the activity of the organism as a whole. And so of the other sense organs.

The individual "talks," he produces sound. If we ask how he accomplishes this marvel, we find that he does it by muscular action. His abdominal muscles squeeze out a blast of air through the vocal cords in his larynx; the muscles of his larynx, acting on certain cartilages to which the vocal cords are attached, stretch the cords, so that they vibrate when the blast

[4] For a fuller account of the subject, the reader may be referred to E. Sharpey-Schafer, *The Endocrine Organs*, 2 vols., 1924 and 1926; and to the brief treatment by B. Harrow, *Glands in Health and Disease*, 1922.

of air passes between them; and the muscles of the mouth and throat open up a cavity which resounds in unison with the vocal cord vibrations, and adds certain mouth tones that give the vowel quality to the sound. Each of these muscles has its motor nerve coming out from the brain or spinal cord; and if that nerve should be cut or broken, the muscle would remain inert, paralyzed. In a study of particular motor activities, such as talking or standing, it would be necessary to examine the muscles, tendons, bones and cartilages — the motor organs — in detail; but for general psychological purposes the most important fact about a muscle is that it has a motor nerve, and so is tied into the general system of the individual's activity.

THE NERVES

When we examine a picture of the nervous system, the first thing that strikes us is that the nerves ramify to every nook and corner of the body; and the second is that they all ramify from the brain and spinal cord. The most curious fact about the nerves, both sensory and motor, is that they all lead to or from the brain and cord. As the brain and cord are continuous one with the other, forming one general center for the whole nervous system, we can say that all nerves run to, or from, this big general center. The only nerve connection between any part of the body and any other, no matter how close together they may lie, is by nerves extending up into this center. When two muscles, or two parts of the same muscle, act together, it is because the center is arousing them both at once through their motor nerves. When a stimulus applied to the skin arouses a response of a muscle, it is by way of a nerve path that leads into the center and out again.

The sensory nerves conduct, or carry stimuli, into the center, and the motor nerves out from the center. The sensory nerves

are aroused to activity by the sense organs, and in turn arouse activity in the center. The motor nerves are aroused by the center, and themselves arouse the muscles. The glandular nerves are like the motor in this respect, and may be classed

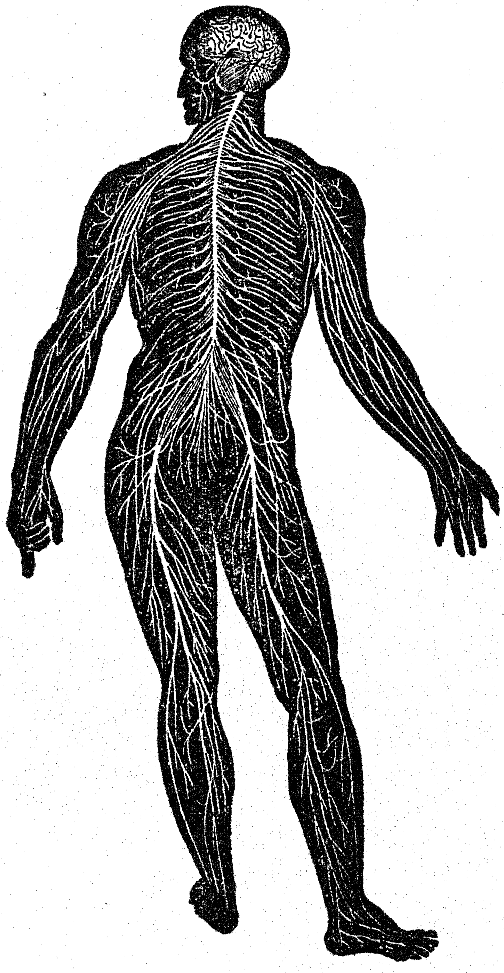


FIG. 61. — (From Martin's "Human Body.") General view of the nervous system, showing brain, cord, and nerves.

with them. The advantage of tying all organs to a common center is evident; the organism is integrated, and behaves as a unit.

Nerve fibers. Though a nerve is a slender cord, it is a bundle

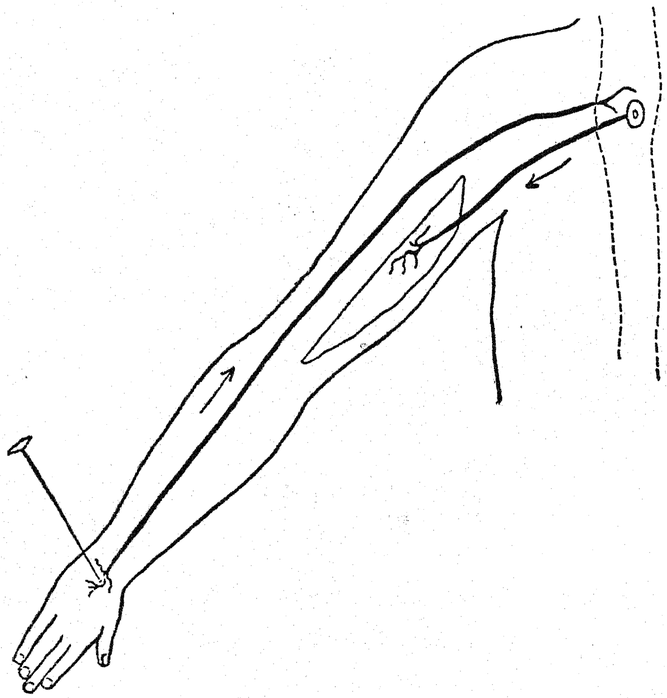


Fig. 62. — The connection from the back of the hand, which is receiving a stimulus, and the arm muscle which makes the response. The nerve center is indicated by the dotted lines.

of many nerve fibers, each of which is a fine thread, microscopic in thickness, but long enough to reach from the sense organ or muscle to the brain or cord. Each nerve fiber is itself made up, like an insulated wire, of a central core enveloped by a sheath. The core is called the *axon,* and there will be more to say of it in a moment. The optic nerve, which is, to be sure, the largest nerve of all, contains 400,000 nerve fibers.

The nerve fiber, though so very fine, breaks up into still finer branches where it terminates in a sense organ or in a muscle. Sensory nerve ends have already been described and pictured,[5] and the motor nerve ends are not very different from the sensory ending shown in Figure 23.[6] The sensory nerve ends are extremely sensitive to stimuli, and the motor nerve ends establish close connections with the muscular tissue which they have to arouse to activity.

The nerve current. What passes along the sensory nerves towards the center, or along the motor nerves away from the center, is something very delicate and only to be detected by very delicate instruments. It is a series of waves, of electrical and chemical nature, weak physically and consuming very little energy, but adequate for the task of arousing other sensitive structures, the nerve center or the muscle or gland. The nerve wave moves along the nerve at a respectable rate of speed, about 130 yards in a second, though at nothing like the speed of electricity along a metal wire.

The nervous system has quite a bit of resemblance to the telephone system of a town. All lines lead to the center, and all connections are made through the center. The nerves are bundles, like the telephone cables, and electric waves, of different sorts, pass along both. The nerve center is more like the automatic type of telephone central than like those requiring an operator. But there are many differences between the nervous system and any telephone system, as the reader will shortly discover for himself.

The all or none law of nerve fiber activity. A gun or a charge of dynamite obeys the all or none law. Either it goes off entirely, or it doesn't go off at all. You cannot graduate the force of the discharge by varying the force of the blow with which you discharge it. If your blow is too weak, it will not discharge any of it, and if it is just strong enough to dis-

[5] See pages 321, 326. [6] See page 323.

charge any of it, it discharges the whole. The charge can differ from one time to another, but whatever charge is there goes off as a whole. Now, to translate this law from guns to nerve fibers, we say that at any instant the nerve fiber has a certain quantity of energy ready to discharge, and any stimulus that is strong enough to arouse the nerve fiber discharges the whole of that energy. Increasing the stimulus would not increase the response of the nerve fiber.

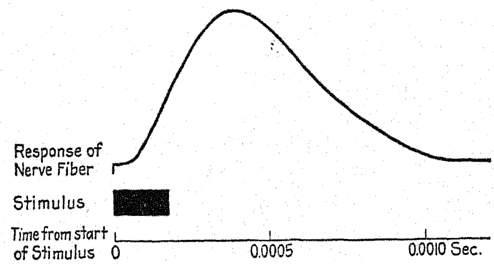


FIG. 63. The single discharge of a nerve fiber. The discharge, or response, starts a very short time after the beginning of the stimulus, increases in strength for a time and then decreases, coming to an end in about 1/1000 of a second. When the discharge is over the nerve fiber rapidly recovers and can be soon discharged again. The discharge moves as a wave along the nerve fiber.

But this law, which has good physiological evidence in its favor,[7] raises psychological difficulties at once. How are we then to account for the fact that the strength of response is graded according to the strength of the stimulus — the fact, in other words, that increasing the strength of a sensory stimulus increases the intensity of the sensation, and the fact that a greater effort gives a stronger muscular contraction?

There are two ways, in spite of the all or none law, in which a stronger stimulus gives a stronger response. First, a stronger stimulus excites a larger number of nerve fibers. Nerve fibers always act in squads, companies and regiments. Even a pin

[7] See E. D. Adrian, *The Basis of Sensation*, 1928, pp. 25–30.

point pressed against the skin cannot limit itself to one single nerve fiber; and the stronger the pressure on the skin, the more nerve fibers will be affected.

In the second place, a stronger stimulus, though it cannot increase the strength of the single wave or discharge, can and does arouse more waves in a given time. The nerve fiber is quick in action; its discharge is over and it is ready for another in a small fraction of a second. A continued stimulus applied to a receptor gives a series of discharge waves in the connected nerve fiber, and the stronger the stimulus applied to the receptor, the greater the frequency of the nerve waves. There may be as few as five nerve waves per second, or as many as two hundred, in the single nerve fiber.

All in all, the intensity of a sensation depends on the number of waves per second delivered by the sensory nerve to the center, this number depending partly on the number of waves per second carried by each nerve fiber, and partly on the number of fibers excited by the stimulus. Similarly, the force of a muscular contraction depends on the number of motor nerve fibers aroused in the center and carrying waves of stimulation to the muscle, and on the frequency of the waves in the single fibers.

The waves in the different motor nerves are the same in character, and they produce different motor effects simply because the nerves run to different muscles. In the same way, the waves in the various sensory nerves — from the eye, the ear, the skin, etc. — are all alike, and the different qualities of different sensations apparently depend on the part of the center to which each sensory nerve leads. The nerve waves in the sensory nerves are even the same as those in the motor nerves. The nerve fiber is a conductor or connector, and that is all. Stimulated at one end, it passes the stimulation along to the structure with which it is connected at the other end.

THE NERVE CENTER

The center of the nervous system consists of the brain and spinal cord. The brain lies in the skull, and the cord extends from the brain down through a tube in the middle of the backbone. Of the brain many parts can be named, but for the present we will mention simply the " brain stem," a direct con-

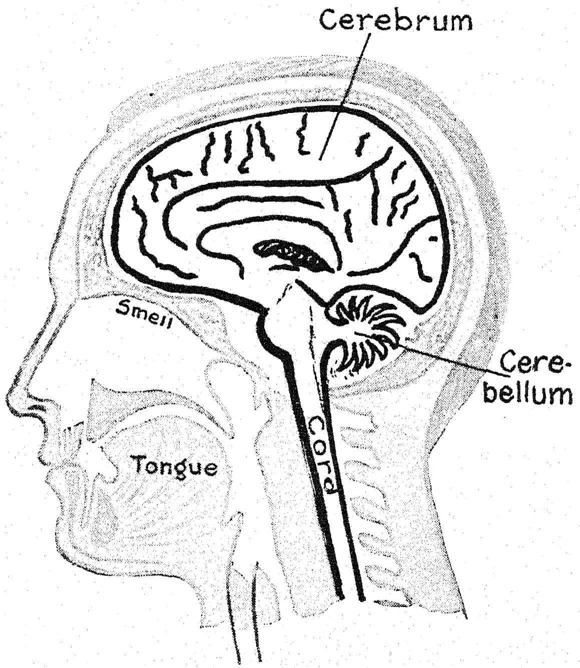


FIG. 64.—Location of the cord, cerebrum and cerebellum. The brain stem continues the cord upward into the skull cavity.

tinuation of the cord along the base of the brain, and the two great outgrowths of the brain stem known as the " cerebrum " and " cerebellum." The brain stem and spinal cord, taken together, are the axis of the whole system. All sensory and

motor nerves tie up with this axis, and all the direct connections of the cerebrum and cerebellum are also with the brain stem and cord. The nerves of the arms and legs and most of the trunk connect with the cord, while the head and face nerves connect with the brain stem, as do also the nerves for the upper part of the interior of the trunk, including the lungs, heart and stomach.

The white matter of the brain and cord consists of nerve fibers connecting the various parts of this big center. The gray matter contains nerve cells and the terminations of nerve fibers, and it is there that the sensory nerve fibers deliver their stimuli, and that the motor nerve fibers get theirs. This vast center is anything but a homogeneous mass. It has hundreds of parts with different structure and connections, and enough is known of its details to fill a library. And still we do not understand it very well, because of its inaccessibility during life, because of the minuteness of its working elements, and because it is unique — different from any apparatus that man has ever designed, and from anything found elsewhere in nature.

THE WHOLE NERVOUS SYSTEM IS BUILT OF NEURONES

The nerves, and the white matter of the brain and cord, as we have said, are composed of nerve fibers, and each nerve fiber consists of a core or axon surrounded by a sheath. Now the axon is an outgrowth from a nerve cell somewhere. In its development it actually grew out of its nerve cell, and it must retain its connection with the cell in order to remain alive and capable of activity.

The whole nervous system is essentially composed of neurones. A neurone is a nerve cell with its branches. Most nerve cells have two kinds of branches, axon and dendrites. The dendrites are short tree-like branches, while the axon may be inches or feet in length.

The axons in the motor nerves come from nerve cells in the cord and brain stem; each one extends from the gray matter of the cord or brain stem out to some muscle. It is stimulated

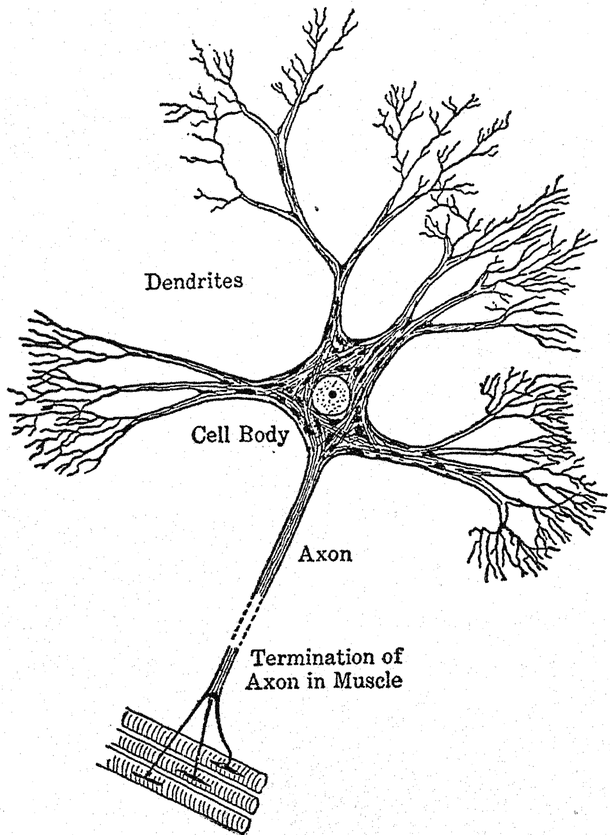


FIG. 65. — A motor nerve cell from the spinal cord, highly magnified.

in this gray matter, conducts nerve waves out to the muscle and arouses a little part of the muscle to activity.

The axons of the optic nerve are branches of nerve cells in the retina, and extend into the brain stem. The rods and cones, when aroused by light, stimulate these nerve cells, and

so start nerve waves along the optic nerve into the gray matter of the brain stem, and arouse some of that to activity. The smell axons are branches of the sense cells in the nose. The axons of the other sensory nerves grow from nerve cells lying in little bunches close to the cord and brain stem. These last

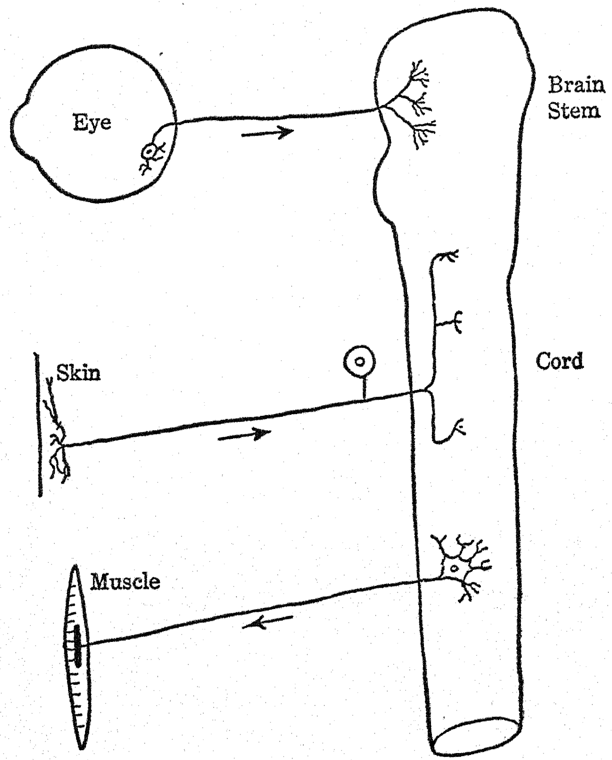


FIG. 66. — Sensory and motor axons, and their nerve cells. The arrows indicate the direction of conduction.

cells have no dendrites, but bifurcated axons which extend in one direction out to the receptors and in the other direction into the gray matter of the cord or brain stem, and so provide a direct path from the receptors to the gray matter.

The number of neurons in the whole nervous system reaches into the billions. Under the microscope each nerve cell is seen to contain, besides the nucleus, such as is present in every living cell and is essential for life and activity, certain peculiar granules — stores of fuel apparently — and many fine fibrils coursing through the cell and out into its axon and dendrites. To understand the use of the fibrils we should have to know more than we do at present regarding the mechanics of the neurone.

THE SYNAPSE

It is in the gray matter that one neurone connects with another. Formerly it was believed that all the nerve fibers were joined into a continuous network, so that the nerve currents could pass freely from one to another. But now it is known that the neurones, which begin their development as little separate round cells, without branches, always remain separate, never actually fusing together, though establishing close contacts. The contact between one neurone and another is called a synapse. The axon of the one neurone breaks up into an

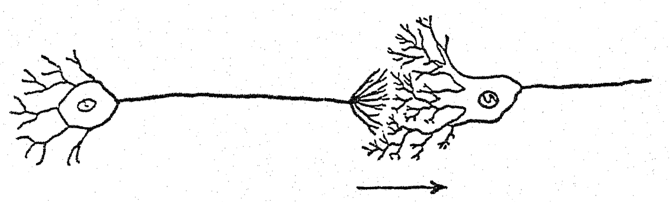


FIG. 67. — The synapse between the two neurones lies just above the arrow.

end-brush of fine branches, which interlace with the dendrites of the other neurone. In some cases, however, the end-brush of the first neurone envelops the cell body of the second neurone. In either case the contact is close enough to enable the first neurone to stimulate the second.

The dendrite in a synapse is a receiving organ, the sense

organ of its own neurone; the axon end-brush in any synapse is a stimulator, not a receiver. What happens at the synapse, then, is that the end-brush of one neurone stimulates the dendrites of another neurone. Communication across a synapse is always in one direction, from the end-brush of one neurone to the dendrites (or cell body) of another.

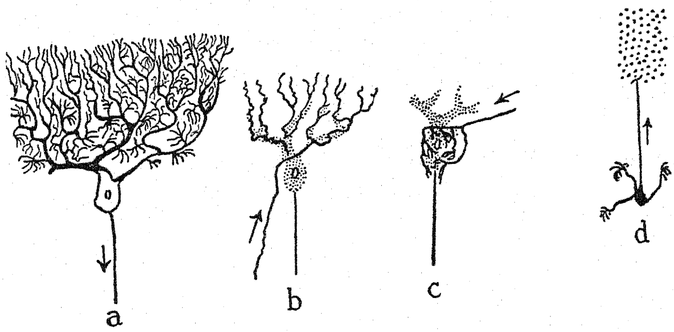


Fig. 68. — Different forms of synapse found in the cerebellum. "a" is one of the large motor cells of the cerebellum (a "Purkinje cell"), with its dendrites above and its axon below; and "b," "c" and "d" show three forms of synapse made by other neurones with this Purkinje cell. In "b," the arrow indicates a "climbing axon," winding about the main limbs of the Purkinje cell. In "c," the arrow points to a "basket" — an end-brush enveloping the cell body; while "d" shows what might be called a "telegraph wire synapse." Imagine "d" superimposed upon "a": the axon of "d" rises among the fine dendrites of "a," and then runs horizontally through them; and there are many, many such axons strung along the dendrites. Thus the Purkinje cell is stimulated at three points: cell body, trunks of the dendrites, and twigs of the dendrites.

Though the contact at the synapses is good, it is not perfect by any means. The nerve waves in the first neurone do not pass freely into the second neurone, but have to take their chance of stirring up a new set of waves in the second neurone. The resistance to free passage of nerve currents varies from synapse to synapse, and in the same synapse from time to time. A synapse may become fatigued by continued activity, and so block a response, and cause a shifting to some alternative response.

Another fact about the synapse, that makes it important in physiological psychology, is that we always find the dendrites of our "second neurone" exposed to the action of several "first neurones." Synapses are always multiple. Several axons come in and terminate in end-brushes close together in the gray matter, and the neurone whose dendrites are just there receives stimulation from all of these axons, which may have come from quite different localities. So the motor neurones in the spinal cord, which directly control the muscles, are acted on by axons from the local sensory nerves, by axons from other parts of the cord and brain stem, and by axons from the cerebrum. The spinal motor neurone is thus exposed to the combined action of all these nerve currents, which may either facilitate or inhibit each other in their effect on the motor neurone.

Thus we seem to find in the synapse the basis for our laws of advantage (one synapse offering less resistance than another), of shifting (fatigue at the synapse), and of combination (axons coming together and synapsing with the dendrites of a single neurone). A somewhat more elaborate and hypothetical scheme is needed to account for the law of selection, or for the intimate nature of inhibition.

As to the laws of learning, nothing would seem more probable than that the end-brushes and dendrites in a much used synapse should grow and so make better connections as the result of exercise, and should atrophy through disuse. Such growth through exercise and atrophy through disuse occur in the muscles and glands, and there is some evidence of them in the brain. Destruction of the retina or optic nerve, occurring early in life, results in under-development of the gray matter in that part of the brain that is most directly connected with the retina. The nerve cells in that area remain small and their dendrites few and meager, because they have not received their normal amount of exercise through stimulation from the eye.

The more a synapse is used, we may believe, the better synapse it becomes, and the better linkage it provides between some stimulus and some response.

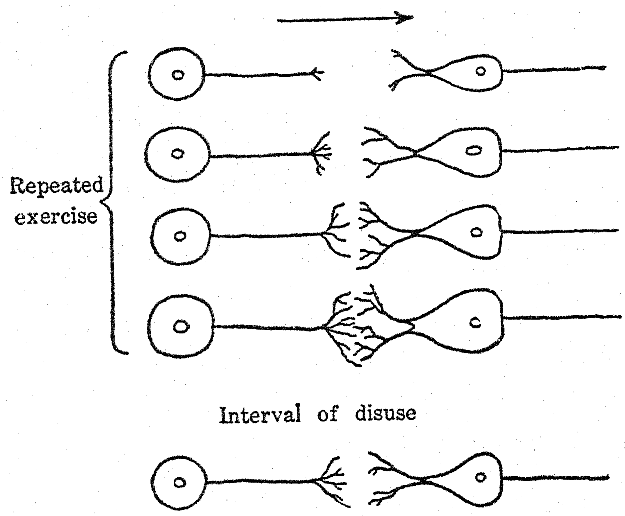


FIG. 69. — The law of exercise in terms of synapse. A nerve current is supposed to pass along this pair of neurones in the direction of the arrow. Every time it passes, it exercises the end-brush and dendrites at the synapse (for the "passage of a nerve current" really means activity on the part of the neurones through which it passes), and the after-effect of this exercise is growth of the exercised parts, and consequent improvement of the synapse as a linkage between one neurone and the other. Repeated exercise may probably bring a synapse from a very loose condition to a state of close interweaving and excellent power of transmitting the nerve current.

BRAIN AND CORD IN MOTOR ACTIVITY

From what has already been said, we are in a position to understand two important facts regarding motor activity, the fact of reflex action, and the fact of movement dependent upon a combination of influences reaching the motor organs from all parts of the nervous system, including the cerebrum. With regard to the second point, there are found in the white matter numerous bundles of nerve fibers connecting various definite

parts of the gray matter. The whole system is knit together into an organization that is definite and yet flexible. So closely knit is it that a simple reflex, uninfluenced by what is going on in the various parts of the nerve center, seldom occurs.

The **reflex arc** is the nerve machine that carries out a reflex. It consists of sensory axons coming in from a sense organ to some part of the gray matter of the cord or brain stem, and forming synapses there with motor neurones whose axons extend out to a muscle or group of muscles. In case of a glandular reflex, the outgoing axons run to a gland instead of a muscle.

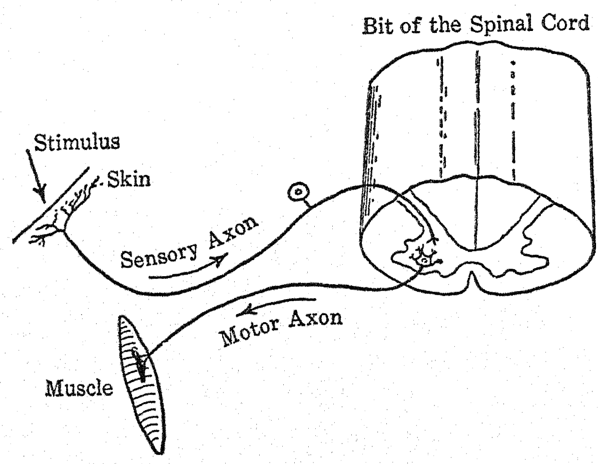


Fig. 70. — A two-neurone reflex arc.

The simplest possible reflex arc consists of one sensory neurone and one motor neurone — or, really, of a team of sensory neurones acting side by side, and arousing in the gray matter of the cord or brain a team of motor neurones. This would be called a two-neurone arc. Often there are three neurones, a central coördinating neurone being present in the gray matter between the sensory and the motor neurones.

Coördination of movement. Study of the gray matter of the cord and brain theme, with its various neurones and their synapses, gives us some notion of the way in which coördinated movement is produced. The question is, how several muscles are made to work together harmoniously, and how it is possi-

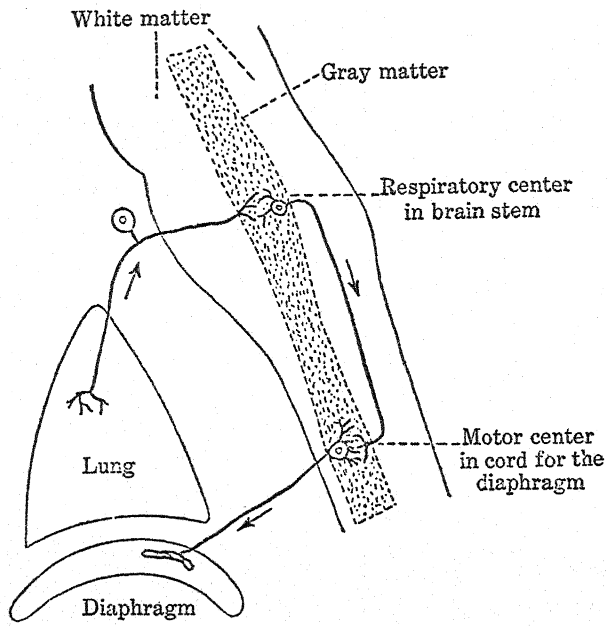


FIG. 71. — A three-neurone arc, concerned in respiration. This also illustrates how one nerve center influences another.

ble that a pin prick, directly affecting just a few sensory axons, causes a movement of many muscles. Well, we find the sensory axon, as it enters the cord, sending off a number of side branches, each of which terminates in an end-brush in synaptic connection with the dendrites of a motor nerve cell. Thus the nerve current from a single sensory neurone is distributed to quite a number of motor neurones. Where there are central neurones in the arc, their branching axons aid in distributing the

excitation; and so we get a big movement in response to a minute though intense stimulus.

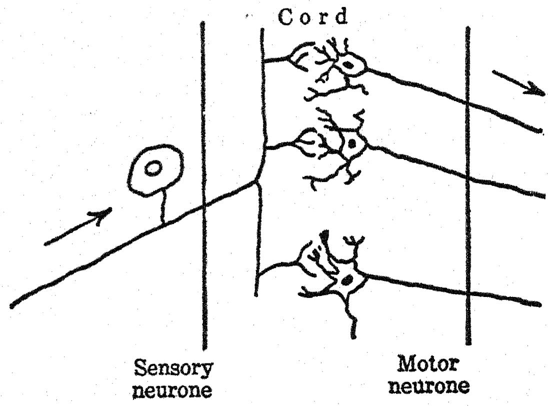


FIG. 72. — Coördination brought about by the branching of a sensory axon.

But the response is not simply big; it is definite, coördinated, representing team work on the part of the muscles as distinguished from indiscriminate mass action. The axons of the

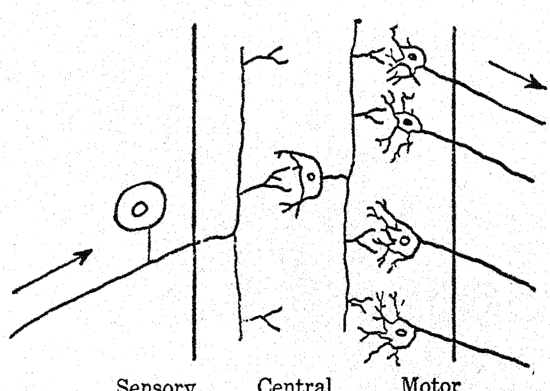


FIG. 73. — Coördination brought about by the branching of the axon of a central neurone.

sensory and central neurones do not connect with any and every motor neurone indiscriminately, but harness together teams that work in definite ways, producing flexion of a limb in the case of one such team, and extension in the case of another. Every reflex has its own team of motor neurones, harnessed together by its outfit of sensory and central neurones. The same motor neurone may however be harnessed into two or more such teams, as is seen from the fact that the same muscle may participate in different reflex movements; and the same sensory neurone may be utilized in more than

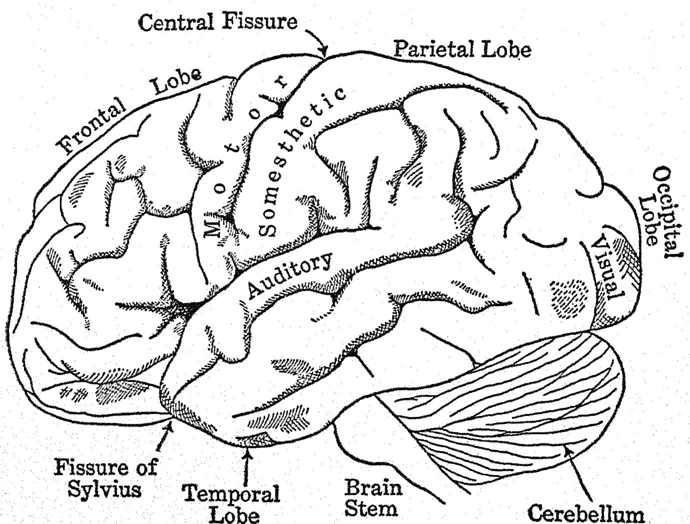


FIG. 74. — Side view of the left hemisphere of the brain, showing the motor and sensory areas (for the olfactory area, see FIG. 77). The visual area proper, or "visuo-sensory area," lies just around the corner from the spot marked "Visual," on the middle surface of the hemisphere, where it adjoins the other hemisphere.

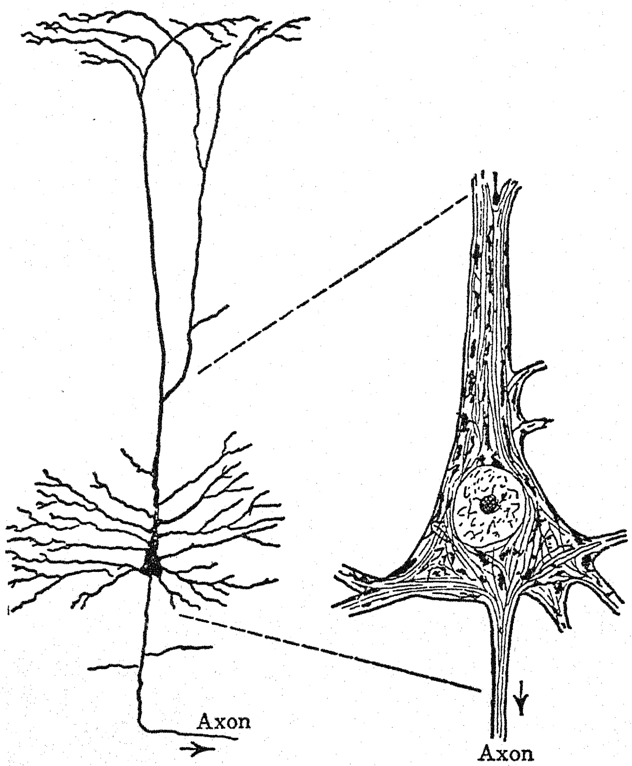
one reflex arc. The most distinctive part of any reflex arc is its central neurones, which are believed to play the chief part in coördination, and in determining the peculiarities of any given reflex, such as its speed and rhythm of action.

The motor area. We now come to the cerebrum and the part it plays in motor activity. The cerebrum is a great outgrowth from the brain stem, larger in man than all the rest of the nervous system put together. It consists of right and left hemispheres, and has a much folded outer surface. The outer layer of the cerebrum, called the *cortex* (bark) is gray matter. Inside the cortex is white matter, consisting of nerve fibers connecting the cortex with the brain stem and cord, and connecting different parts of the cortex with one another.

Though no part of the cortex is directly connected with either the muscles or the sense organs, several parts are indirectly connected; that is, they are directly connected with parts of the brain stem and cord that are themselves directly connected with the muscles and sense organs. That part of the cortex that is most closely connected with the muscles is the *motor area.* This is a long, narrow strip of the cortex, lying just forward of the central fissure. If you run your finger over the top of the head from one side to the other, about halfway back from the forehead, the motor areas of the two cerebral hemispheres will lie close under the path traced by your finger. The motor area in the right hemisphere is connected with the left half of the cord and so with the muscles of the left half of the body; the motor area of the left hemisphere similarly affects the right half of the body. Within the motor area are areas for the several limbs and other motor organs. Thus, at the top, near the middle line of the head (and just about where the phrenologists located their "bump of veneration"!), is the area for the legs; next below and to the side is the area for the trunk, next that for the arm, next that for head movements, and at the bottom, not far from the ears, is the area for tongue and mouth.

The largest nerve cells of all are found in the motor area, and are called, from their shape, the "giant pyramids." They have large dendrites and very long axons, which latter, running in a

thick bundle down from the cortex to the brain stem and cord, make up the "pyramidal tract," the most direct line of communication from the cortex towards the muscles.



Giant pyramid cell from the motor area of the cerebral cortex, magnified 35 diameters

Cell body of same further magnified

FIG. 75.—(After Cajal.) Type of the brain cells that most directly control muscular movement.

The motor area with its pyramidal tract forms a sort of funnel through which all parts of the cortex can have an influence on muscular activity. The motor area is aroused by axons

coming into it from other parts of the cortex; its own axons, thus thrown into activity, carry the stimulus down to the motor cells in the gray matter of the brain stem and cord; and these in turn send out nerve waves to the muscles. The same group of motor cells in the cord, with the coördinating central

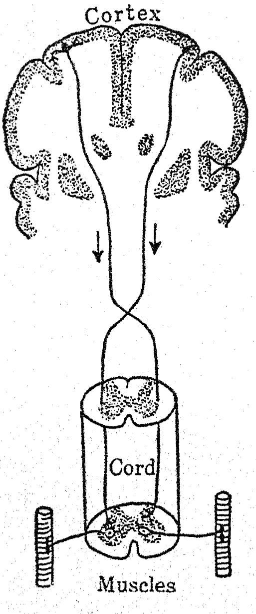


FIG. 76. — The nerve path by which the motor area of the cortex influences the muscles. The upper part of this path, consisting of axons issuing from the giant pyramids of the motor area and extending down into the spinal cord, is the pyramidal tract. The lower part of the path consists of axons issuing from the motor cells of the cord and extending out to the muscles. The top of the figure represents a vertical cross-section of the brain, such as is given, on a larger scale, in Fig. 77.

cells that go with them, can be aroused reflexly, i.e., by a sensory nerve, and give the flexion reflex, or can be aroused by the motor area through the pyramidal tract, and then give a voluntary flexion of the leg.

The story is told of a stranger who was once dangling his

legs over the edge of the station platform at a small backwoods town, when a native called out to him "Hist!" (hoist), pointing to the ground under the stranger's feet. He "histed" obediently, which is to say that he voluntarily threw into play the spinal center for leg flexion; and then, looking down, saw a rattler coiled just beneath where his feet had been hanging. Now even if he had spied the rattler first, the resulting flexion, though impulsive and involuntary, would still have been aroused by way of the motor area and the pyramidal tract, since the movement would have been a response to *knowledge* of what that object was and signified, and knowledge means action by the cerebral cortex, which we have seen to affect movement through the medium of the motor area. But if the snake had made the first move, the same leg movement on the man's part, made now in response to the painful sensory stimulus, would have been the flexion reflex.

The motor area not only initiates movements, but it can either facilitate or inhibit reflexes.[8] The knee jerk furnishes good examples. So purely reflex is this movement that it cannot be duplicated voluntarily; for, though the foot can of course be voluntarily kicked forward, this voluntary movement does not have the suddenness and brevity of the true reflex. For all that, the cerebrum can exert an influence on the knee jerk. Anxious attention to the knee jerk inhibits it; gritting the teeth or clenching the fist reinforces it. Now the reflex machine that carries out the knee jerk consists of sensory axons from the thigh muscle, running in to motor neurones in the cord, whose axons run back to the muscle. The cortex, acting by the motor area and the pyramidal tract, facilitates or inhibits these spinal motor neurones.

Thus the cortex controls the reflexes. Other examples of such control are seen when you prevent for a time the natural regular winking of the eyes by voluntarily holding them wide

[8] See page 232.

open, or when, carrying a hot dish which you know you must not drop, you check the flexion reflex which would naturally pull the hand away from the painful stimulus. The young child learns to control the reflexes of evacuation, and gradually comes to have control over the breathing movements, so as to hold his breath or breathe rapidly or deeply at will, and to expire vigorously in order to blow out a match.

The coughing, sneezing and swallowing reflexes likewise come under voluntary control. In all such cases, the motor area facilitates or inhibits the action of the motor neurones in the brain stem and cord.

Posture and the cerebellum. Most movements initiated by the cerebrum involve some disturbance of posture, and it is important for the organism that this shall not mean a disturbance of equilibrium. Here is where the cerebellum plays its part in the life of the organism, superimposed as it is upon a lot of machinery in the cord and brain stem having to do with maintaining postures. A single muscle, stretched to a certain length, tends to maintain that length by a steady reflex contraction that requires no effort and consumes very little energy. The sensory axons taking part in this elementary postural reflex are those of the muscle sense, and there are more complex muscle sense reflexes tending to keep the head and body in line and to maintain easy, unconstrained postures, as in lying. Nerve fibers coming into the brain stem from the vestibule and semicircular canals of the inner ear, stimulated by head positions and movements, give postural reflexes that tend to keep the individual right side up and steady. Here, then, we have elaborate reflex machinery for maintaining posture and equilibrium against gravity. But the moment you turn your head, bend your body, swing your arms, walk or run, lift a heavy object, climb a tree, walk on your hands, or execute any of the numerous agile performances that we see in men and animals, your movement cuts

across all this fine reflex machinery for maintaining postures. It is all very well for the cerebrum to say to the spinal cord, "Kick that ball," but if the spinal cord took account of only that command, it would land the individual in an unexpected posture. Along with the sudden action of some muscles must go a steady action of others, and the posture must be modified just right to maintain equilibrium while permitting the desired movement to occur. This, as we said, is where the cerebellum plays its part, though it is not easy to see exactly how it does it. Numerous incoming axons register in the cerebellum the existing posture of the individual, and outgoing axons enable the cerebellum to produce effects in the brain stem and cord and through them on the muscles. Then we find an enormous bundle of axons coming from the cortex of the cerebrum, and indicating that the cerebrum activates the cerebellum. What goes on may be something as follows. When the cortex of the cerebrum, which certainly has the initiative in most motor activity, is initiating a movement, it discharges in two directions, (1) by way of the motor area and pyramidal tract, and (2) by way of the cerebellum. The pyramidal message to the cord amounts to "Kick," the message to the cerebellum amounts to "Look out, he's going to kick." This message to the cerebellum, combining with the posture as already registered there, yields a modification of posture that exactly fits the active movement.

HOW THE CEREBRUM OPERATES

Since we have ventured on a conception of the action of the cerebellum, we need not recoil even from the cerebrum, though it is a much more complex and difficult organ to understand. Let no one tell you that we know nothing about the cerebrum, for to assimilate what is known would take years of study; and let no one tell you that the cerebrum simply acts as a whole, for that is either a figure of speech or a gesture of

despair. Different areas of the cortex do have different connections, and different functions, though it does not follow, by any means, that every type of behavior or mental activity has its own circumscribed cortical area, nor that every different performance has its own little spot in the cortex that "presides" over it. The best conception is that the brain acts in patterns, and that each pattern may bring into activity several or many groups of neurones in different parts of the cortex. Corresponding to the many varieties of the individual's knowing and doing, there must be many brain patterns, all different, though not neatly localized in separate bits of the cortex.

Methods of studying the brain. So intricate a subject has to be approached by a combination of methods of investigation. You study the anatomy of the brain, especially by the aid of the microscope. You compare its structure in different animals, and correlate the structure with their behavior. You follow its growth in the individual, and correlate that with his behavior development. You turn to the physiologist, who tries to observe the brain in action, who stimulates each part of an animal's cortex with weak electric shocks, to see if any movements result, or who removes a part to see what loss of behavior results. You turn finally to the clinician and the pathologist, who work together on the results of diseases, tumors, gun-shot wounds and other injuries to parts of the brain in man. The vast experience gained during the World War with small injuries from bullets and shell splinters, in young healthy brains, has cleared up many points that were doubtful before. The result of a century of work, by all these methods, has been to show that there are certain areas of the human cortex that are definitely connected with the senses and with movement. The motor area has already been mentioned.

The sensory areas. Lying parallel with the motor area on the other side of the central fissure is a narrow strip called the "somesthetic area," connected with the skin and muscle

senses. Destruction of any part of this area brings loss of the sensations from a certain part of the body.

A small part of the temporal lobe is the auditory area. If it is destroyed, in both hemispheres, the individual is deaf. He may still make reflex responses to loud noises, but consciously he does not hear at all: he has no auditory sensations.

A small part of the occipital lobe, at the rear of the cerebrum, is the visual area, one in each hemisphere. If these are both gone, the individual is blind, though his brain stem still executes the pupillary reflex to light. Localization within the visual area is very precise, for each point of the retina is connected with a certain point in the occipital lobe. The two retinas are, however, superposed in the visual area, so that the right half of each retina is connected with the visual area of the right hemisphere, and the left half of each with the visual area of the left hemisphere. The two visual areas act together, so that no discontinuity is experienced when an object moves from side to side across the field of view.

There is an olfactory area in a rather secluded part of the cortex, connected with the nose, and probably there is somewhere a taste area, not yet located.

To understand the connections of these sensory areas, we must recall that no portion of the cortex is directly connected with any sense organ or muscle. The cortex is connected only with the brain stem and cord. The axons leading into the sensory areas come from a portion of the brain stem called the interbrain, or sometimes the thalamus. The fibers of the optic nerve end here, form synapses with nerve cells in the gray matter of the interbrain, and from these latter cells axons arise which pass back to the visual area of the cortex. Somewhat similarly, the ear, the skin and the muscle sense are connected with the interbrain, and by relay fibers thence to the cortex. Exactly what is accomplished by this big intermediate center for the senses remains a mystery, though it certainly

appears that the interbrain has something to do with emotion and feeling.

What does the rest of the cortex do? When you subtract from the cortex those limited areas that are directly connected with the senses and with movement, you find that you still have most of it to account for. This is true even of the monkey's brain, more true of the chimpanzee's, and still more of

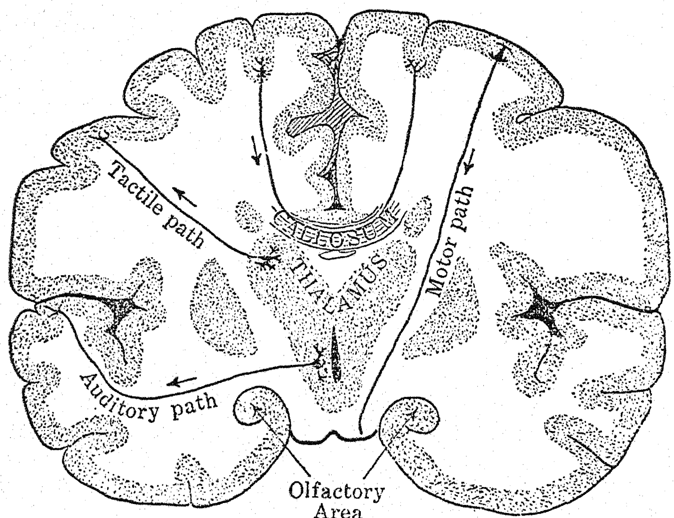


FIG. 77. — Vertical cross-section through the brain, showing the cortex on the outside, the thalamus and other interior masses of gray matter, some of the paths to and from the cortex, and the callosum or bridge of axons connecting the two cerebral hemispheres. The "Motor path" is the pyramidal tract, only the beginning of which is shown here, its further course being indicated in FIG. 76.

man. We might conjecture that all this remaining cortex had to do with "higher mental processes," or with learned behavior. The physiological method of studying these areas merges into a psychological method. An animal first learns to do a certain trick, then a part of his cortex is removed, to see whether he has lost the trick, and whether, if so, he is still capable of relearning it. The results of this line of study have

been rather baffling, since sometimes the removal of a portion of the cortex does deprive the animal of the trick, and yet he can readily learn it again afterwards. If the removed portion

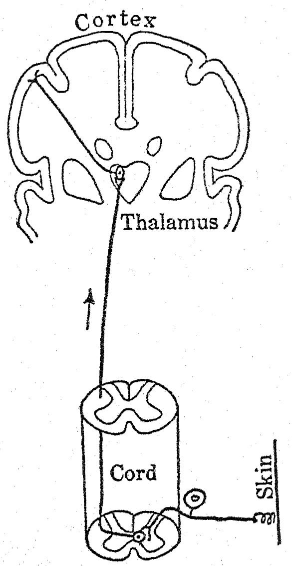


FIG. 78. — Sensory path from the skin of any portion of the trunk or limbs. The path consists of three neurones, the cell body of the first lying just outside the spinal cord, that of the second lying in the cord, and that of the third lying in the thalamus. The last part of this path is the "Tactile path," shown in FIG. 77.

was the area that "presided" over that type of performance, then how could the animal learn the same performance without this area? Evidence of this sort has led some investigators to conclude that one area is equivalent to another, the only question being *how much* cortex the individual has to learn with. An alternative, and perhaps a better conclusion is that the cortex operates in wide-spreading patterns, so that the operation of removal necessarily very crude, is more likely to disturb the pattern the larger the piece removed. But we must allow a certain flexibility to cortical patterns, as well.[9]

[9] See S. I. Franz, *Psychological Monographs*, 1911, no. 56; K. S. Lashley,

When we turn to the evidence from injuries to human brains, we find plenty of disturbances of more or less specific activities. We find *aphasia,* loss or disturbance of speech, different forms of it in different cases. Through brain injury it sometimes happens that a person loses his ability to speak words, though he can still make vocal and articulate sounds. The cases differ in severity, some being able to speak only one or two words that from frequent use have become almost reflex (swear words, or "yes" and "no"), while others can pronounce many single words but cannot put them together into sentences. In other cases, while the person is fluent enough, and uses words enough, he does not use the right words to express his meaning. One old gentleman mystified his friends by declaring he must "go and have his umbrella washed," till it was discovered that he wanted his hair cut. Or, again, while speech may be rapid, the words are jumbled together without grammar in a perfect jargon. The part of the brain injured in aphasia varies somewhat, but is usually in the left hemisphere of right-handed persons, and on the side of the hemisphere in the general neighborhood of the auditory area.[10]

Apraxia, or loss of ability to "do," is akin to aphasia. An individual who shows no paralysis of movement may become unable, through a brain injury, to execute any fairly complex purposive act, such as lighting a candle or cutting with scissors. In other cases, though performing these brief acts, he cannot carry through a longer performance, such as setting the table or frying an egg. The injury, here again, varies in location, but is usually in the neighborhood of the motor area, either in front or behind it.

Journal of Comparative Neurology, 1926, vol. 41, pp. 1–58; C. J. Herrick, *Brains of Rats and Men,* 1926; N. Cameron, *Psychological Monographs,* 1928, no. 177.

[10] H. Head, *Aphasia and Kindred Disorders of Speech,* 2 vols., 1926.

Agnosia, or loss of ability to "know" or perceive, can be divided into visual, auditory and somesthetic, according to the sense field affected. Visual agnosia has many different forms, such as inability to recognize seen objects, or to grasp spatial forms and figures, or to match colors. The injury here is in the neighborhood of the visual area. In auditory agnosia, the person cannot recognize sounds, or he cannot follow music, though formerly a good musician. The injury here is in the neighborhood of the auditory area. In the somesthetic type, with injury near that sensory area, the individual cannot recognize objects placed in his hand, judge weights by lifting, etc.

It appears, then, that the cortex adjacent to the area for each sense is concerned in the perception of facts by that sense, and also that the region near the motor area is concerned with skilled movement. In view of the large amount of recovery from these losses that often occurs, though the loss of brain substance is not repaired, we are driven back to our notion of brain patterns ramifying widely through the cortex. The pattern aroused by a visual stimulus radiates from the visual area, by connecting axons, and involves the immediately surrounding regions strongly.

The large region lying between the visual, auditory and somesthetic areas seems to be a sort of expansion of those areas, a field for the development of patterns of response to sense stimuli. By analogy, we might guess the large frontal lobe to be an expansion of the motor area, and a field for the development of action patterns, which would mean the organization and planning of motor activity. There is some slight evidence for this conception, as the behavior after frontal lobe injury is apt to be characterized by abulia and also by impulsiveness and irresponsibility.[11]

The extraordinary richness of the cerebrum in cells and

[11] H. Piéron, *Thought and the Brain,* 1927.

their interconnections, as dimly suggested by two of the accompanying pictures, affords all the leeway we could possibly desire for our "patterns." These patterns, it should be added, while not fixed by heredity, do get fixed to some extent by learning, so that the same groups of neurones are used, time after time, whenever the same familiar object is recognized

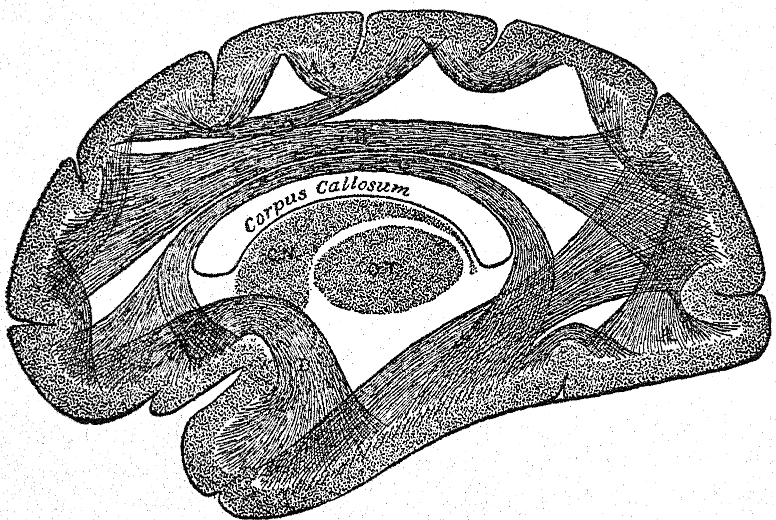


FIG. 79. — (From Starr.) Axons connecting one part of the cortex with another. The brain is seen from the side, as if in section. At "A" are shown bundles of comparatively short axons, connecting near-by portions of the cortex; while "B," "C," and "D" show bundles of longer axons, connecting distant parts of the cortex with one another. The "Corpus Callosum" is a great mass of axons extending across from each cerebral hemisphere to the other, and enabling both hemispheres to work together. "O. T." and "C. N." are interior masses of gray matter, which can be seen also in FIG. 77. "O. T." is the thalamus.

or the same familiar skilled act performed. Injury to one of the neurone groups that participate in a fixed pattern demolishes the pattern, but does not preclude the relearning of it with only a slight amount of substitution of fresh neurones for those destroyed.

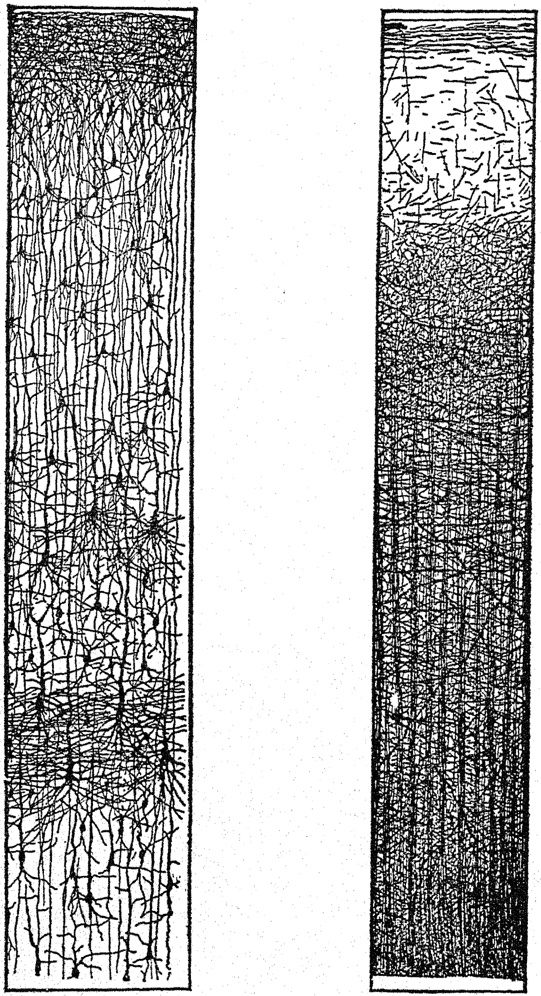


FIG. 80. — (From Cajal.) Magnified sections through the cortex, to show the complexity of its inner structure. One view shows nerve cells and their dendrites, with only a few axons, while the other shows axons, outgoing and incoming, and some of their fine branches. Imagine one view superimposed upon the other, and you get some idea of the intricate interweaving of axons and dendrites that occurs in the cortex.

THE PHYSIOLOGY OF EMOTION

Our previous study of emotion [12] ran into physiology to some extent, and we have here simply to take up the thread, and tell something of the part played by the nervous system.

The autonomic nerves. These are the nerves that run to the heart, blood vessels, lungs, stomach, intestines and other viscera, and also to the sweat glands, the little muscles of the hairs, and the iris of the eye. They run, that is, to the "smooth muscle," a slower-acting, but more automatic type of muscle than that of the limbs, and they run also to glands. These nerves are composed of extra-slender nerve fibers, which grow out from cells in the brain stem and cord, and so are part of the general nervous system, not a separate system as was formerly believed. There are three divisions of the autonomic, upper, middle and lower. The upper division grows out from the brain stem, and consists principally of the "vagus" or wandering nerve, which, among other effects, slows the heart beat, but stimulates the glands of the stomach to pour out the gastric juice, and the muscular wall of the stomach to make its churning movement. Thus the upper autonomic is active in digestion, and the emotional mood that goes with it is calm and comfortable. The middle division of the autonomic consists of the "sympathetic" nerves, which come out from the spinal cord at the level of the chest, and which have the opposite effects on the heart and stomach to those of the upper division. The sympathetic hastens the heart and retards or checks stomach activity, and has other effects which were described before under the head of fear and anger. The sympathetic also overlaps in its distribution with the lower automatic, and antagonizes the latter's effects on the pelvic organs.

The autonomic is certainly under the influence of the cortex,

[12] See pages 292–298.

directly or indirectly, since something you think of may hasten or slow the heart, may make you blush or pale, may help or hinder digestion. So it is interesting to learn that there is a little part of the interbrain that is a sort of higher center for the autonomic nerves. This fact becomes the more interesting when we learn that many students of the brain are convinced that the interbrain is somehow concerned in emotion. Injuries to the interbrain often produce uncontrollable laughing or weeping. We also know that the interbrain receives the sensory pathways on their way to the cortex. If we let our minds play about these facts, we are led into the following speculation as to the nature of emotion. Emotion is the reaction that occurs when sensory nerve currents, instead of reaching the cortex, are left to diffuse from the interbrain into whatever channels they find open, and some of them get into this neighboring autonomic center and so start up the internal changes characteristic of emotions. This would happen when the cortex, concerned with the "brainy life of relation,"[13] is blocked or disturbed in its activity, so as not to absorb the sensory currents from the interbrain.

THE PHYSIOLOGY OF MOTIVATION

We spoke before of organic needs as important motivating factors, and told how they acted as stimuli to internal sensory nerves and so aroused motor activity. There is no difficulty in understanding the *continuance* of such a motive. As long as the organic state of thirst continues, it acts as a sensory stimulus, and accounts sufficiently for continued restless activity.

But when the individual has got started on some particular action, and persists in it, in spite of distracting stimuli, till he has brought it to a conclusion, no organic need is specific enough to account for his doing that particular thing. If anything, the organic need would drive him restlessly from one

[13] See page 309.

specific act to another. Our formula, it may be remembered,[14] was that an activity in progress did not need any motivation from outside itself, since it tended to complete itself. What can be the mechanism of the persistence of an incomplete activity? What is the physiology of "preparatory set"? These questions cannot be answered with certainty, but we can see some possibilities.

One possibility is that the persistence of an activity is due to the sensory stimuli produced by any muscular response. Any movement of the organism stimulates the muscle sense, at least, and so starts fresh stimuli running into the nerve center. In walking, for example, each step with the right foot produces sensory stimuli that may be the cue for the left foot to step. In maintaining a posture, the muscle sense is stimulated by the steady contraction of the muscle, and so provides sensory stimuli to the nerve center; and these stimuli are necessary for the continued postural reflex of that muscle. Based upon such instances, a theory of motivation would look to the constant backflow of sensory impulses from the muscles to account for the persistence of the activity in progress.

Another possibility is that the nerve center, itself, may continue in activity, once aroused, and not lapse instantly into inactivity the moment a stimulus ceases. While a nerve fiber does come to rest very promptly when the stimulus to it ceases, the sense organs do not do so, as indicated by after-images. At the synapse between one neurone and the next, some damming up of the nerve current may occur, somewhat as it does in an electric condenser. In a small way, at least, this effect certainly occurs at the synapse, for a series of stimuli gives a summation effect there. Even if the persistence of activity in a single neurone or group of neurones could not continue more than a few seconds, without further stimulation received, a large pattern of activity might be maintained by

[14] See page 265.

the interplay of stimulation between different groups in the nerve center. In revery, A reminds you of B and B of C, and so on, without any indication that the shifting activity goes outside the brain. It is all rather speculative, to be sure, but there really is no reason to suppose that a complex brain pattern lapses instantly as soon as the stimulus that aroused it ceases. Such a pattern is a disturbance of the state of equilibrium, and there is no reason for supposing that the equilibrium of a complex system must be instantly regained as soon as the external disturbance (stimulus) ceases. So there are plenty of possibilities, and we need not worry for fear that motivation and purposive activity could have no explanation in physiological terms.

PHYSIOLOGY OF LEARNING

There are two main facts to explain, or to describe in physiological terms, and one of them, the improvement of a neural mechanism by use or exercise, has already been dealt with in discussing the synapse. The other is the conditioned reflex. In trying to conceive what may go on in the brain during the conditioning process, we shall follow Pavlov rather closely, just as he unwittingly followed in the footsteps of the psychologists James (1890) and McDougall (1905). The theory amounts to a fitting together of a few simpler theories or hypotheses, for most of which there is some evidence quite apart from the facts of learning.

1. Any part or mechanism of the brain that has been aroused to action discharges its energy into other parts of the brain or else into the nerves that go out from the brain towards the muscles and glands.

2. The sensory mechanisms of the brain discharge into, or towards, the motor and glandular mechanisms. This generally accepted fact is called the "law of forward direction" in the sequence of brain activities. Activity gets into the brain

by sensory channels, and escapes from the brain by motor (and glandular) channels, and within the brain the movement of active energy is from the sensory mechanisms towards the motor mechanisms.

3. The discharge of an active sensory mechanism may be either diffuse or concentrated. It is diffuse when there is no motor mechanism closely connected with the active sensory mechanism nor in a condition of readiness to receive stimulation. If, however, there is some motor mechanism either closely connected with the active sensory mechanism or else in a condition of readiness to receive stimulation, then the discharge of the active sensory mechanism is concentrated upon this motor mechanism and arouses it to activity.

4. When a mechanism is just becoming active, it is very receptive of stimulation. It tends to absorb any nerve currents that come its way.

With these assumptions in mind, let us suppose the following situation to arise. A sensory mechanism, awakened to strong activity, but having no open route for concentrated discharge, is slowly diffusing its energy, when a motor-glandular mechanism starts into activity. The result is that a large part of the sensory activity is discharged into the motor-glandular mechanism. No matter by what stimulus the motor-glandular activity is started, it attracts to itself the energy of the just-previously aroused sensory mechanism. Thus, to be concrete, the sensory activity aroused by the bell discharges into the feeding mechanism aroused to activity a few seconds later by the presence of food in the dog's mouth. So the connections between the bell-hearing mechanism and the feeding mechanism, though not at all close, are actually used and exercised. Now we need to add another to our list of assumptions, namely:

5. The use or exercise of weak connections from a sensory to a motor mechanism strengthens those weak connections.

Repeated use improves the weak connections still more, till finally they become strong enough to concentrate the discharge of the sensory mechanism upon the motor mechanism in question, and when this state of affairs has been reached, activity of this sensory mechanism produces activity of this motor mechanism, without the assistance of any other stimulus. Thus the salivary activity becomes attached to the bell stimulus.

We have been thinking only of the *establishment* of the conditioned reflex, but our theory would be not only incomplete, but radically false, if we left out of account the *extinction* of the conditioned reflex. From all we have said thus far, one would expect the conditioned reflex, once well established, to remain stable. Further exercise, even without food following the bell, should only further strengthen it. But as a matter of fact, that is the way to extinguish it. When this peculiar fact was discussed before, we related it to the check-up by the environment or external situation. We also pointed out the importance of active inhibition as an aid in explaining the extinction of the conditioned reflex. When an established conditioned reflex is being extinguished, the sequence of events is: bell — flow of saliva — no food — suspension or inhibition of saliva. We need therefore to add to our previous list of assumptions just one more:

6. Inhibition, being an active brain process, is subject to the same laws as other activities. A sensory activity, ready to discharge just when inhibition is starting up, discharges into this inhibitory process, and becomes attached to it in the same way that it becomes attached to a more positive activity. Whether a sensory activity shall get tied up with a positive activity or with the inhibition of this activity depends on which of these two is the main process going on during the discharge phase of the sensory activity. If inhibition predominates over positive activity, the main linkage of the

sensory activity will be with the inhibition. If the environmental check-up favors the positive activity — as it does when food is given — then the bell becomes attached to the positive activity; but if the environmental check-up favors inhibition, as when no food is given, then the bell becomes attached to the inhibition of the feeding activity.

INTELLIGENCE AND THE BRAIN

There is certainly some connection between the brain and intelligent behavior. While the spinal cord and brain stem vary according to the size of the body, and the cerebellum with the motility of the species of animal, the size of the cerebrum varies more or less closely with the intelligence of the species. It does vary also with bodily size, as illustrated by the whale and elephant, which have the largest cerebrum of all animals, including man. But the monkey, which shows more intelligence than most animals, has also a very large cerebrum for his size of body; and the chimpanzee and gorilla, considerably surpassing the ordinary monkeys in intelligence, have also a much larger cerebrum. The cerebrum of man, in proportion to the size of his body, far surpasses that of the chimpanzee or gorilla.

The cerebrum varies considerably in size from one human individual to another. In some adults it is twice as large as in others, and the question arises whether greater intelligence goes with a larger brain. Now, it appears that an extremely small cerebrum spells idiocy; not all idiots have small brains, but all men with extremely small brains are idiots. The brain weight of quite a number of highly gifted men has been measured in post-mortem examination, and many of these gifted men have had a very large cerebrum. On the whole, the gifted individual seems to have a large brain, but there are exceptions, and the relationship between brain size and intelligence cannot be very close. Other factors must

enter, one factor being undoubtedly the fineness of the internal structure of the cortex. Brain function depends on dendrites and end-brushes, forming synapses in the cortex, and such minute structures make little impression on the total brain weight.

Intelligence, while undoubtedly a cerebral affair, does not have its particular area in the cortex. It depends on the effective working of the whole cerebrum. Somewhat the same can be said of memory, which could not conceivably have any special area or center, since we remember all sorts of facts, visual, auditory, tactile, motor.

LEVELS OF DESCRIPTION

Having now tried our hand at a physiological description of the organism's activities, let us ask what is the difference between the physiological and the psychological description of the same performance of the individual. In a rough way, the difference is clear enough. The psychological description says that an individual sees an object, or speaks a word, or feels angry, and relates this fact to other facts in his behavior. The physiological description dissects seeing, speaking, and feeling angry into the action of numerous organs and cells. It is much more detailed, but it is a description of the same activity of the organism.

Now when the individual is participating in a social or group activity, such as an election or a football game, we can have a social description as well. The sociologist would take the group as a unit, and describe its behavior, the psychologist would describe the behavior of each individual in the group, and the physiologist would describe the activity of each organ of the individual. All would be describing the same actual occurrence, each from his own point of view, or, we may put it, at his own level of description.

The football game might be described as consisting of the

interlocked activity of two social groups, the opposing teams, without any mention of the individual players. Team A, having the ball, first tries a certain mass formation, which advances the ball only a yard, and follows this by a certain open play, which loses ground, but is tried again with the same result. Team A then forms for a kick, but team B breaks through and captures the ball. And so on. The game might also be described as consisting of the activities of twenty-two individual players, the position of each at the start of every play and his action during that play being set forth. Such a description would be rather too detailed to enable the reader to follow the game, and would be very blind indeed if all reference to the social grouping — to the teams — were rigidly excluded, and the individual players were simply named in each case. We should lose sight of the wood for the trees. Yet the psychologist might argue that his was the only true description, since the teams are certainly composed of individuals.

Along comes a physiologist, and insists that description in terms of individuals is extremely crude, since the individual is composed of organs; and he might proceed to describe the same game by referring to the hearts, lungs, nerves, muscles and glands of the players. His description, if at all complete, would fill the Sunday newspaper, and would certainly contain much valuable information, but would be a disappointment to any reader who wanted to know about the game. And the organ physiologist might be followed by the cell physiologist, insisting that each organ is really composed of cells, and starting to describe their several activities; by the chemist, insisting that cell activity is really the motion of molecules and atoms; and finally by the physicist, insisting that the motion of an atom is really, really composed of the movements of the constituent proton and electrons.

Each of these descriptions would be a true description of the same action, yet all would be different. Each might be

complete, in its own kind, and leave no gaps in the action described, and yet each would tell something the others did not tell. Each would reveal relationships that were not brought out by the others, the interaction of the teams in one description, of individuals in another, of organs, of cells, of molecules and atoms, of electrons. If the aim of science is to see facts in their relations, then each of these descriptions is scientific, and one is just as scientific in its aim as another.

Each science views nature from a different level, much as an aviator might examine the country from different elevations. If he flew at an elevation of a hundred feet, he would see many details that he would lose if he ascended to a thousand feet, but only from the greater elevation could he see the broad features of mountain and valley.

To change the figure of speech, we may say that different sciences examine the same real thing under different magnifications. It is like examining a flower first by the naked eye, and then through a microscope. The microscope reveals much that cannot be seen by the naked eye, but loses sight of the flower as a whole. Any complete description or adequate conception of the flower requires the putting together of what is observed at different magnifications. So, a complete description of human life requires the synthesis of what physics and chemistry have to tell about it, of what physiology has to tell, of what psychology has to tell, and of what the social sciences have to tell.

Psychology observes life with a medium magnification, or from a medium elevation. Physiology observes it in more detail, and sociology in broader outline, than psychology. The central position of psychology is a position of advantage and also of responsibility. Psychology has the advantage of being in close touch, on one side or the other, with all the studies of life. Psychology has the responsibility of bridging the gap between biology and the social sciences. To do its part in the

world's work, it must labor assiduously at its own level, while maintaining good contact with the levels just above and just below. Physiological psychology is an effort to maintain contact between the study of the individual and the study of his organs and cells; and social psychology is a similar effort in the other direction.

EXERCISES

1. Which of the endocrine glands have the most obvious effects upon
   (a) muscular activity,
   (b) mental activity,
   (c) emotional activity?

2. Show how the circulation and the nervous system operate together in producing the internal activities and changes that occur in fear and anger.

3. Point out resemblances and differences between the nervous system and a telephone system.

4. About how long does it take a sensory nerve current to run from the hand to the spinal cord?

5. Judging from the speed of nerve conduction and from the time required for a simple reaction, can you judge whether this latter time is consumed more in the nerve fibers or more in the gray matter?

6. Draw a diagram of the cord and brain stem, with the nerves and also with the cerebrum and cerebellum.

7. Draw a diagram of a motor neurone of the spinal cord, with its axon extending out to a muscle.

8. What part of the nervous system lies (a) in the forehead, (b) in the very back of the head, (c) along the base of the skull, (d) within the backbone, and (e) in the arm?

9. Draw a diagram of the motor path from the cortex to the muscle, indicating where a synapse occurs.

10. Draw a diagram of the sensory path from the retina to the visual area, indicating where a synapse occurs.

11. What structures make up the gray matter, and what elementary physiological processes go on there?

12. Show that active motor performances bring into play an elaborate nerve mechanism.

13. What is your understanding of the facts of localization of function in the brain cortex?

14. The three divisions of the autonomic system, and the organic and emotional states connected with each division.

15. Restate the theory of emotion in the light of physiology.

16. Which of the physiological interpretations of psychological facts, given in this chapter, seem to you fairly satisfactory, and which unsatisfactory or blind?

17. Would a purposive act be any less purposive, if it were completely described in physiological terms?

REFERENCES

Of the numerous physiological books that might be mentioned, some have already been mentioned in the footnotes, and the following one may be added:

C. J. Herrick, *An Introduction to Neurology,* 4th ed., 1927.

CHAPTER XIII

PERSONALITY

THE INDIVIDUAL AS A WHOLE, AND HIS SOCIAL ADJUSTMENTS

People differ not only in intelligence and efficiency, but in an intangible something referred to as "personality." If your acquaintance is applying for a certain position, and has named you as one of his references, you will be asked by the appointing officer to tell what you know of the candidate's experience, his knowledge and skill in the field where he desires a position, his character and habits, and his *personality*; and in replying you state, if you conscientiously can, that the candidate has a pleasing and forceful personality, that he gets on well with superiors, equals and inferiors, is coöperative, energetic, ambitious without being selfish, clean, modest, brave, self-reliant, cheerful, optimistic, equal-tempered; and you perhaps include here traits that might also be classed under the head of "character," as honesty, truthfulness, industry, reliability, and traits that might be classed under physique, as good appearance and carriage, commanding presence, a "strong face," and even neatness and good taste in dress. Here we have an array of traits that are of great importance to the individual's success in his work, in his social relationships and in his family life; and it is a proof of how much remains to be accomplished in psychology that we cannot as yet present anything like a real scientific analysis of personality, nor show on what elementary factors it depends.

We even find it difficult to answer that fundamental question that was set up in our first chapter as a question to be asked

whenever we encountered a noun in psychology. We said then that, since psychology was a study of activities, the nouns were names of activities and should be translated back into verbs, or adverbs. There is no handy verb to fit the noun, "personality," and when we consider what we mean by crediting anyone with a strong or cheerful or modest personality, we see that there can be no one verb to fit the case, and that "personality," like "intelligence," is properly an adverb, or a collection of adverbs. Personality refers not to any particular sort of activity, such as talking, remembering, thinking or loving, but an individual can reveal his personality in the way he does any of these things. When we think of his personality, we have in mind some quality of his total behavior. If a little act reveals the personality, it is because the individual has acted in this little matter just as he acts in larger ones. Personality, then, is the quality of the individual's total behavior, it is how he acts, when his activity is taken as a whole.

FACTORS IN PERSONALITY

Physiological and social psychology meet in the study of personality. The individual's biological make-up has something to do with it, and so does his social environment. Biologically, he has certain needs, such as that for food, which he looks to the environment to satisfy; and the environment, in the case of human beings, is a social, or at least a socialized environment. But the environment is not altogether easy for him to manage; it offers obstruction to the satisfaction of his demands, and it makes demands upon him, which sometimes conflict with his own demands, or are difficult for him to meet because of his own limitations. The difficulty and conflict are so severe at times that the individual hates his social environment and would like to live alone, but on the whole, whether by nature or by early conditioning, he prefers society to solitude, and in fact one of his own demands is that for society.

He must adjust himself to his social environment, with its demands and its opposition to his own demands; or he must adjust the environment to suit himself; or both. Meanwhile, the social group, such as his family, is adjusting itself to him and endeavoring to adjust him to itself. It can readily be imagined that the problem of *adjustment* is an important personal problem, and that the development of the individual's personality consists largely in a series of adjustments. The factors that determine what kind of an adjustment shall be made reside partly in the individual and partly in the environment.

The individual's *physique* is a factor in his personality. In ordinary life, mental and physical traits are not sharply distinguished, and probably they cannot be distinguished except in the abstract. The mere size of a person affects his attitude towards other people and their attitude towards him — and it is in such social relations that personality most clearly stands out. His size affects the individual's behavior in subtle ways, since the big fellow dominates others easily just by virtue of his size, and so tends to be good-humored, while the little fellow is apt to be strenuous and self-assertive. Muscular development and "looks" also have their effect on personality.

Another factor might, by a sort of play on words, be called *chemique*. This corresponds to what is often called *temperament*, a very obscure matter psychologically. We speak of one as having an excitable temperament, a jovial or a sour temperament. The ancients attempted to relate the "four temperaments" to the four great "humors" or fluids of the body. Thus the sanguine individual was one with a surplus of blood, the choleric had a surplus of bile, the phlegmatic a surplus of phlegm, and the melancholic a surplus of black bile or spleen; and any individual's temperament resulted from the balance of these four. Sometimes a fifth tempera-

ment, the nervous, was admitted, dependent on the "nerve fluid."

This particular chemical derivation of temperament is, of course, out of date, being based on very imperfect knowledge of physiology; but it still remains possible that chemical substances carried around in the blood have much to do with the sort of trait that we think of under the head of temperament. Only that today, with some knowledge of the endocrine glands, we should be inclined to connect temperament with them. The irritable individual may be one with over-active adrenals, the strenuous individual one with a very active thyroid. All in all, it seems likely enough, though far from proved, that the hormones have much to do with the elusive traits that we refer to as temperament.

The organic needs and other dependable motives, listed in an earlier chapter,[1] and also any need or interest that the individual may have developed, are demands which he makes upon the social environment, and factors in his personality. We can easily see that poor appetite for food, or strong sex appetite, or great resistance to fatigue, are personal traits that affect social behavior. One individual is more sociable than another, or more masterful and aggressive, or more tender and motherly, or readier to laugh; these differences, due as they are partly to heredity and partly to previous environment, are positive factors in personality.

The individual's *limitations,* as well as his demands, are factors in personality. A person of limited intelligence is likely to be lacking in such personal traits as tact and sympathy, because he does not understand what is going on in a social group, does not see what other people want and cannot imagine himself in their place. A stable, cheerful moron may be said to have a good personality, if you will, but hardly a fine or superior personality. When children of high intelli-

[1] See page 246.

gence are studied on a large scale, they are found [2] on the whole to be healthy, happy and well-adjusted individuals. Intelligence is certainly an asset in adjusting difficult conflicts and so in building up personality.

But intelligence is a liability also, strange as it may seem. The more intelligent person demands more of his environment, and more is demanded of him; and the heavier the demands, the more difficult the adjustment. An intelligent boy, employed to do humdrum work, quickly loses interest, falls into indolent ways, or becomes restless and dissatisfied. In school, when a child is placed in a grade much too low for his mental age, he may get into mischief or develop a habit of daydreaming that is rather undesirable. At home, the bright little child may be babied too long and form undesirable habits of dependence. In any large school system may be found a few children of very high IQ whose personalities are poor, some timid, some domineering, some babyish, some too much grown up, some unstable. One is crowded too hard by parents proud of having such a brilliant child, another is kept from social contacts because she is "superior to the other children of the neighborhood." There are several ways in which a parent can mishandle a bright child and make it unusually difficult for him to make useful social adjustments and develop a healthy personality.[3]

Personality tests. Valiant efforts are being made to locate and measure characteristics of the individual that are factors in personality. A test for social intelligence proceeds much like the familiar group test for general intelligence, except that it calls for judgment as to people's motives and emotions, and as to the best way to handle social situations demanding tact and good management.[4] A test for "ascendance-submission" calls on the subject to state his customary reaction to a

[2] L. M. Terman, *Genetic Studies of Genius*, 1925, vol. I, pp. 363–555.
[3] C. B. Zachry, *Personality Adjustments of School Children*, 1929.
[4] F. A. Moss, *Applications of Psychology*, 1929.

great variety of concrete situations in which one may dominate or be submissive and retiring, something like the following: [5]

"Do you take the lead in introducing strangers at a social gathering — always, sometimes, never?

"Do you insist upon a tradesman's giving you good service — always, sometimes, never?"

Ingenious tests for honesty in certain types of situation afford the subject what looks like a safe chance to cheat, while still getting a check on his behavior.[6] Persistence of motives, though not measured as yet by any test, appears to be a definite factor entering into the individual's personality and affecting his success.[7] The effort in these and many other beginnings is to find traits, additional to intelligence, that are important in their influence on conduct.

Personality types. From early childhood, we have a way of classifying people as belonging to divergent types, the good and the bad, the tall and the short, the bright and the dull, and the concept of a continuous gradation of individuals from one extreme to another, without real separation into classes, is a difficult concept to get and to use consistently. In the cases of intelligence and of imagery, we have already seen [8] that continuous gradation corresponds to the facts. In the study of personality, where the facts are still rather vague, and where tests for exact measurement are still scarce, it is easy to fall into the old habit of speaking of types. Very interesting suggestions have been made of personality types under which people can be grouped. Most interest has been awakened by the suggestion that people fall into the two opposed types of *introvert* and *extrovert* with an intervening

[5] G. W. Allport, *Journal of Abnormal Psychology*, 1928, vol. 23, pp. 118–136.

[6] H. Hartshorne and M. A. May, *Studies in Deceit*, 1928.

[7] E. Webb, *British Journal of Psychology, Monograph Supplement*, 1915, vol. 1, no. 3; C. Spearman, *The Abilities of Man*, 1927, p. 348.

[8] See pages 37–39, 111.

group of ambiverts. By definition,[9] extroversion is interest in external things, and introversion interest directed inwards, to oneself, to one's thoughts and dreams. But the formal definition has been left behind somewhat, as the idea has developed, and as difficulties have arisen in placing individuals under the right "type." External interest, by definition, ought to include interest in persons and in things, and so we should expect to find that individuals greatly interested in persons and in social doings were also interested in plants and animals and machines, and should make the best mechanics and the best scientific observers. But it was soon found that many individuals who were extremely objective in this sense were not particularly sociable; so that interest in natural phenomena or in machinery has come to be listed among the introvert traits. In sizing up a person for introversion-extroversion, you are supposed to answer such questions as the following:

Does he limit his acquaintances to a select few?
Are his feelings easily hurt?
Is he suspicious of the motives of others?
Does he keep in the background on social occasions?
Does he prefer to work alone rather than with other people?
Is he easily embarrassed?
Does he avoid anything like public speaking?

The Yes answer to these questions is supposed to indicate introversion. The questions so far all refer to sociability, social ease, zest for dealing with people. Then there are other, quite different questions, such as:

Does he worry over what may happen?
Is he introspective?
Does he day-dream?
Is he absentminded?
Does he become very much absorbed in any object he is looking at or manipulating?
Is he slow and hesitant in reaching decisions?

[9] C. G. Jung, *Psychological Types*, translated by H. G. Baynes, 1924.

Here again, the positive answer is supposed to indicate introversion, while the opposite behavior characterizes the extrovert.

On the face of it, there are two quite different interests lumped together here, interest in people, and liking for thought and absorption. Interest in people and dislike for thought and absorption are supposed to go together and indicate the extrovert; lack of interest in people and liking for thought and absorption are supposed to go together and indicate the introvert; but, up to date, no one has proved that they do go together. The extrovert is said to make the best salesman, but that is because he is interested in people and has abundant self-assurance in meeting people, rather than because of any special dislike for thought and absorption. Writers, artists and scientists are supposed to be mostly introvert, yet some of them are sociable enough, what they require being the liking for thought and absorption. This whole subject is new and not well worked out, but one may at least harbor a doubt whether introversion, as so far conceived, does not cover two independent traits.

Classifying everybody as either an extrovert or an introvert is bad, anyway, for even those who are most enamored with the type theory admit a middle class of ambiverts, and admit that this middle class is large, if not the largest of the three. Whenever any large group of people has been tested or rated by the use of a list of questions similar to those cited,[10] a continuous gradation has been found, from the introvert to the extrovert extreme, with the greatest number of individuals in the middle range. So we have no more excuse for classifying people into these two, or three, types than we have for classifying them as geniuses and feeble-minded, with a " mixed type " in between.

[10] E. Heidbreder, *Journal of Abnormal Psychology*, 1926, vol. 21, pp. 120–134.

Another question to raise is whether the same individual consistently maintains his standing at a certain point of the introversion-extroversion scale, or varies from time to time and according to the particular situation. Certainly he varies according to the situation, and probably also from time to time in the same situation, according to his mood.

In short, while the idea of introvert and extrovert types is well worth while because it makes us observe people from a new angle, there are several objections to the doctrine of types here, as well as in other fields. If anyone wants a first rough index of introversion as against extroversion, let him ask himself whether this discussion has led him to speculate whether he himself is introvert or extrovert, or whether it has led him to classify his acquaintances.

Another interesting suggestion proposes to classify people under the *cycloid* and *schizoid* types, with various mixtures.[11] Cycloid means having cycles (of mood), and schizoid means separated or withdrawn from the world. The terms, and the whole idea, come from the two prominent types of insanity that are not dependent on the invasion of the organism by germs or poisons. These are manic-depressive insanity (cycloid) and dementia precox (schizoid). An individual with manic-depressive insanity [12] has many normal periods, but at times he passes into a manic or excited condition, which may last for months, and at other times he passes into a depressed state. In the manic state, he is lively, hilarious, voluble, sometimes irascible, and darts from this thing to that without dwelling on anything. In the depressed state, he is sad and brooding, and anything but lively in his behavior. Now, among normal people, there are some who oscillate between more lively and more depressed states, while never becoming

[11] E. Kretschmer, *Physique and Character*, translated by W. J. H. Sprott, 1925.

[12] See above, page 374.

so lively or so depressed as to be impossible in a social environment, and such people may be said to belong to the cycloid type. Besides their tendency to oscillation, people of this type are characterized by directness of contact with the environment, and by sociability. They seem to correspond, roughly at least, to the extroverts in the other system of types.

The dementia precox patient is withdrawn from the environment, sometimes to such a degree that he seems to pay no attention to anything that is said or done to him. Among normal people are found some who are somewhat withdrawn, especially from the social environment. Some of them are regular sensitive plants, and close themselves against any contact that is the least bit rough, while others appear rather cold and aristocratic. They do not oscillate like the cycloids, but they may break loose at times from their reserved and rather inactive state. The schizoid type seems to correspond rather closely to the introvert.

Since manic-depressive insane patients are commonly of a rounded type of physique, while dementia precox patients run rather to an elongated shape, usually weak though sometimes athletic, it has been suggested that the cycloid behavior type goes with the rounded physique, and the schizoid behavior type with the elongated physique. As hard-headed psychologists, we should accept all these suggestions as a stimulus to thought and observation, but by no means as established facts.

Social or environmental factors in personality development. If personality develops by adjustment between the demands of the individual and the demands of the environment, then we must not close our discussion of factors in personality without taking some notice of the environmental factors. These of course are numerous, and change from time to time in the individual's career. At birth, he has to

adjust himself to a very novel environment, but the adjustment is made as easy for him as possible by the people about him. His wants are supplied with little effort on his part. As time goes by, adults do not do so much for him, he is weaned and becomes less dependent in many ways, though often after a struggle. Adults do not yield to his demands quite so readily as they did, and if he plays with other children, they do not yield to him at all readily. If a baby brother or sister comes along, so that he is no longer the "little king of the house," an adjustment is necessary which some children find very difficult, but others easy enough, according to their temperament and intelligence and the way the adults in the family manage the transition. Where one child hates the baby as a usurper, another is proud of being so grown up as to have a baby to watch over.

There are adjustments all along the road. Entering school is one mile-stone at which children have their troubles. With adolescence, the individual's own demands increase, while the demands of society upon him increase as well. Vocational adjustment is sometimes troublesome to him, and any close comradeship, such as that of marriage, brings new problems of adjustment. When the married couple have a child, there is a very definite adjustment problem for them, as well as for the baby; and when the child reaches adolescence and asserts his independence, the parents as well as the child are faced with what is sometimes a difficult problem of adjustment.

The environmental factor in developing the individual's personality consists largely of the demands of other people conflicting with the demands of the individual himself. Sometimes these external demands are so excessive that the individual can scarcely adjust himself to them; sometimes they are reasonable, but his own demands are excessive. Good humor and social intelligence can solve most problems of this sort,

but sometimes the social intelligence has to be supplied by some third party who views the problem from outside and in the light of similar problems of other people which he has studied.

MALADJUSTMENTS AND THEIR TREATMENT

If adjustment is easy and successful, little is heard of it, so that our information on the important process of adjustment comes largely from studies of cases of difficult adjustment which have come to the attention of social workers, psychiatrists and psychologists — or to clinics where all three work together — and have been studied, treated, and followed up. Maladjustment takes several forms.

The individual may seek to escape from his problem, either by actually running away, or by withdrawing as far as possible from the troublesome social contacts, and shutting himself in to his own daydreams, in which he has things as he wants them. The resulting *shut-in personality* is likely to be socially ineffective, though in some instances beautiful, poetical imaginings emerge. Another form of escape is by way of *invalidism,* which is well illustrated by the " shell shock " cases during the War. These young soldiers were subjected to terrific demands from the social environment, with almost insuperable conflict, one would suppose, between these social demands and the individual's own demand for life and safety. The wonder is that so large a majority came through the strain with their adjustment maintained. But in some cases, the strain was too severe. A sharpshooter had a little crevice in the front wall of the trench to which he climbed to take a shot at the enemy. But the enemy discovered his crevice, and as soon as he climbed up, well-aimed bullets struck very close at hand. He stood this for a while, and then went blind, not because of any injury to his eye or brain, but because his adjustment gave out. He was not "malingering," or pretending. Others

in similar situations developed paralysis of the legs or some other disability. Similar cases happen in civil life, and are called "hysterical" blindness or paralysis. The line between such disabilities and frank malingering is not perfectly sharp, and there are many cases of invalidism that are mostly malingering.

Another sort of maladjustment may be described as poor compensation. If the individual's demands are denied, he may recoup himself by getting his way somewhere else. If his fellows neglect him, he may compel their attention by some mischief or extravagant behavior. Better, he seeks some performance in which he can shine. If he must be wholly subservient on his job, he perhaps recoups himself by excessive domineering at home. Though many such efforts at compensation are ridiculous, the general scheme of giving up where you must, and finding some substitute satisfaction, is often the best line of adjustment available.

Ways of helping maladjusted individuals. Without being able here to go into this subject at all fully, we may glean a few points of psychological interest. A child's maladjustments are handled quite directly. The outside adviser secures the child's confidence, and enlists his coöperation in an effort to see what the trouble is, and how it started — what the conflicting demands are that have not yet been properly adjusted. If the problem arises in the home, or leads back into the home, as most problems of young children do, then the coöperation of the people at home must be secured, and often their behavior as well as that of the child needs to be modified. The general principle is to get the facts of the situation clearly before the parties concerned, and to work out a solution in the light of all the facts. The persons concerned need to face the facts and not dodge them, as they may incline to do.

The maladjustments of an adult cannot be handled so directly as those of the child, because their sources may lie

far back in the individual's experience, and may have been forgotten. The invalidism of the adult may be a bid for sympathy, and may be essentially a trick he earned while a child. An irrational fear may date back to childhood. If old memories can be resuscitated,[13] so that the original facts can be faced and an adjustment of the original situation worked out in retrospect, the subject often regains his self-confidence and turns to his present situation with a free and open mind. But sometimes the original situation cannot be recovered by memory. Even then, it may be reconstructed with some probability from what is known of the individual's childhood, together with what is commonly observed in other children, and sometimes this general picture of the situation in which the maladjustment arose is of value to the troubled adult.

There are two main steps in psychotherapy, as the treatment of maladjustments may be called. The first step is this which has been mentioned, the seeking the origin of the difficulty in the case history of the individual, and getting him to see and face these facts. The second step looks to the present and future, and seeks to get the individual to set his face towards health and well-adjusted living. There are several methods of psychotherapy.

Suggestion and hypnotism. A suggestion is an idea, or plan of action, adopted by the individual without calling it into question.

Suggestion may be exerted by a person, or by the circumstances. If by a person, the more prestige he enjoys in the estimation of the subject, the greater his power of suggestion. A prestige person is one to whom you are submissive. A child is so dependent on older people, that he is specially susceptible to prestige suggestion.

Suggestion exerted by the circumstances is about the same

[13] See pages 100–102.

as what is often called "auto-suggestion" or "self-suggestion." A man falls and hurts his hip, and, finding his leg difficult to move, adopts and follows the suggestion that it is paralyzed.

"Counter-suggestion" applies to cases where a suggestion produces the result contrary to what is suggested. You suggest to a person that he should do a certain thing, and immediately he is set against that act, though, left to himself, he would have performed it. Or, you advance a certain opinion and at once your hearer takes the other side of the question. Quite often skilful counter-suggestion can secure action, from children or adults, which could not be had by positive suggestion or direct command.

Suggestion works when it gets response without awakening the resistance which might be expected, and counter-suggestion when it arouses so much resistance that the suggestion itself does not have the influence which might be expected. In terms of stimulus and response, suggestion works when a particular stimulus (what is suggested) arouses response without other stimuli being able to contribute to the response; and counter-suggestion works when a stimulus (what is suggested, again) is itself prevented from contributing to the response. In counter-suggestion, response to the suggestion itself is inhibited, and in positive suggestion response to other stimuli is inhibited. Both involve narrowness of response, and are opposed to what we commonly speak of as "good judgment," the taking of all relevant stimuli into account, and letting the response be aroused by the combination.

One person is more suggestible than another, and the same person is more suggestible at certain times, or in certain states, than otherwise. The most suggestible state is hypnosis, which is a passive and sleeplike state that is nevertheless attentive and concentrated. It appears as if the subject were awake at just one point, namely at the point of relation with the hypno-

tizer. To stimuli from other sources he is inaccessible. His field of activity is narrowed down to a point, though at that point he may be intensely active.

The depth of the hypnotic state varies from shallow to profound. Comparatively few individuals can be deeply hypnotized, but many can be got into a mild receptive state, in which they accept suggestions. The waking person is alert, suspicious, assertive, while the hypnotized subject is passive and submissive. The subject's coöperation is necessary, in general, in order to bring on the hypnotic state, whether shallow or deep.

The means of inducing hypnosis are many and varied, but they all consist in shoving aside extraneous thoughts and stimuli, and getting the subject into a quiet, receptive attitude, with attention sharply focussed upon the operator.

When the subject is in this state, the suggestions of the operator are accepted with less criticism and resistance than in the fully waking state. In deep hypnosis, gross illusions and even hallucinations can be produced. The operator hands the subject a bottle of ammonia, with the assurance that it is the perfume of roses, and the subject smells of it with every appearance of enjoyment. Loss of sensation can also be suggested and accepted. Being assured that his hand has lost its sensation and cannot feel a pin prick, the subject allows his hand to be pricked with no sign of pain. Paralysis of the arm or leg can be similarly suggested and accepted.

Acts may be suggested and performed. The subject is handed a cardboard sword with the assurance that that is a sword, and directed to attack some person present, which he does with the appearance of serious intent.

Now, however, let the subject be given a real sword with the same command as before. Result — the subject wakes up! A suggestion that runs counter to the subject's organized character cannot get by without awakening the subject. Con-

sequently, there does not seem to be much real danger of crimes being performed by innocent persons under hypnosis.

In mild hypnosis, the above striking phenomena are not produced, but suggestions of curative value may be conveyed, and so taken to heart that they produce real results. Hypnosis may be employed in both of the main steps of psychotherapy, to revive memory of the original source of the trouble, and to get the subject imbued with the idea that he is going to be well. Hysterical paralysis or blindness can sometimes be suggested away quite readily. As individuals differ in suggestibility, what works with one will not always work with another. Many psychotherapists avoid the use of hypnosis because, as they say, it does not get to the root of the trouble. It may remove a symptom, without curing the underlying maladjustment, and so the trouble breaks out in some new form.

The *psychoanalysis* of Freud makes a strong point of getting to the root and origin of the trouble, by reviving memories. The subject relaxes and becomes as uncritical as possible, and lets memories and thoughts come as they will, except that they must not wander entirely off from the matter in hand, which may be the analysis of a dream and finding what of personal significance lies behind it.[14] When the subject seems to be holding something back, the analyst warns him that embarrassing or apparently trivial material must all be allowed expression. The result is the revival of old experiences involving sex desires and malicious desires. At different times, from childhood on, there have been conflicts of desires that were not faced and adjusted, but evaded by suppressing them from consciousness. These experiences, especially the earliest available of them, must now be revived and worked over. After the subject has thus come to know the desires and conflicts that underlie all his difficulties, he practices for weeks in handling the difficulties of his present life, with frequent

[14] See page 484.

conferences with the analyst, and when he can meet his present problems with ease and confidence, the treatment is complete.[15]

Where Freud seeks the main source of conflicts in the sex impulse, broadly interpreted as covering all desire for affection and for pleasure, Adler in his *individual psychology*[16] seeks the origin of conflicts in the mastery impulse, or desire for power and superiority. Even the little child demands power and mastery, but, being often thwarted in this demand, may come to have a feeling of inferiority. This feeling is much more than the word expresses; it is a feeling of being beaten and ridiculed by a hostile world, a feeling that may be expressed in the words, "I'm beaten, going to be beaten, I won't play." He refuses to play the game, thus restoring in some measure his sense of superiority, and he proceeds, if he is hard hit, to invent his own game, a game in which he can win, since he makes the rules to insure that result, and since he plays it alone as far as possible. In extreme cases, he sees in everything that society expects of him — to rise in the morning, to sleep at night, to trust any one or accept any responsibility — a hostile demand which he evades by not playing the game. The particular rules of his own private game differ according to the family situation in which he first invented them, according to whether he was an only child, an oldest child, a youngest child, and so on. The task of the psychologist, or physician, who is trying to help such an individual is, through conversations on his difficulties in life, to discover the particular game he is playing, to lead him to see the same, and, while not trying at all to force him out of his little game, to lead him to sense power and superiority in playing the big game in which the social group is engaged.

[15] D. Forsyth, *The Technique of Psycho-analysis*, 1922; I. S. Wechsler, *The Neuroses*, 1929, pp. 268–277.
[16] A. Adler, *Individual Psychology*, 1924, pp. 23–31, 317–326.

A sense of inferiority, either physical or mental, is apt to affect the personality unfavorably. It does not necessarily produce humble behavior; far from that, it often leads to a nervous assertiveness. An apparently disdainful individual is often really shy and unsure of himself. Put a man where he can see he is equal to his job and at the same time is accomplishing something worth while, and you often see considerable improvement in his personality.

In distinction from the psychotherapeutic methods already mentioned, that of faith cure, with which we may class Coué's autosuggestion, has much less of scientific and medical background, and yet it deserves attention because it sometimes gives good results, and because the whole field of psychotherapy is far from being well explored by science. This type of method omits altogether the first step in psychotherapy, the seeking the origin of the subject's difficulties, and starts with the second. It tries to lead the subject to set his face squarely and confidently towards health and good adjustment. It does not exhort the subject to make an effort to improve, but seeks to get him to take in the glowing idea of health, of all being well, of "getting better and better every day." Since this method works with some subjects, we have to conclude that that business of digging up the past is not necessary for all individuals, especially for the large and important class who suffer from minor maladjustments.

In this brief review of maladjustments and their treatment, we have seen weak, cowardly and sneaky personalities emerge from facts not squarely faced, from problems evaded, from conflicts not promptly adjusted, and we have seen such personalities improved by going back and belatedly facing the facts and making the adjustments.[17] We may conclude that stronger and better-adjusted personalities result from solving each life problem as it arises, with a sense of solidarity with

[17] E. Bagby, *The Psychology of Personality*, 1928.

the group and a determination to stay in the game. If we turn back to the case history presented in the very first chapter, we see there a strong personality emerging from a series of adjustments that were sometimes difficult — adjustments to school, to a broken home, to marriage, to the life of an author.

INTEGRATION AND DISINTEGRATION OF THE PERSONALITY

Though the individual is always in one sense a unit, there is a sense in which he needs to achieve unity. His desires do not always pull together, and in fact some necessarily pull against others. So that we sometimes say of a person that he is behaving so differently from usual that we should not know he was the same person. We speak of one person as being well integrated, meaning that he is always himself, his desires being so coördinated as to work reasonably well together; whereas of another we speak as poorly integrated, unstable, an uncertain quantity. Integration is achieved partly by selection from among conflicting impulses, partly by coördination, partly by judicious treatment of those impulses that are denied; as was explained under the head of motivation.[18]

The individual has in a sense two or more selves, one for his business, one for his home, one for his club; and it may happen that the interests dominating him in these relations are different, so that a man who is hard and grasping in business is kind and generous to his wife and children. "Dr. Jekyll and Mr. Hyde" gives an extreme picture of such lack of integration, a picture rather fanciful than drawn from real life.

But we do find in real life cases of *dissociation* of the personality, also called cases of double or multiple personality. The individual passes from one state to another, behaving very differently in the two states, and usually unable to remember in the primary or more lasting state what he has done in the secondary state. In the secondary state he remembers what

[18] See page 271.

he did in the primary state, but is apt to speak of it as if done by another person. In many cases, the primary state seems limited and hampered, as if the individual were not his complete self, while the secondary state is a sort of complement to the first, but decidedly imperfect in itself. Thus in the primary state the individual may be excessively quiet, while in the secondary state he is excessively mischievous. He seems to act in fractions, and never as a whole.

Often the secondary state likes to have a name for itself and to be considered as a secondary personality, as if two persons were inhabiting the same body — a fanciful conception. The secondary personality will even assert that it stays awake in the background and watches the primary personality when the latter is active, spying on it without that personality being aware of it. Thus two fractions of the individual would be acting at the same time, but still not working together as a unit.

This claim of the secondary personality has been experimentally checked up by Dr. Morton Prince, in the following way. He was able to cause his subject, a young woman, to pass from the primary to the secondary state and back again, by a procedure resembling hypnotism. While she was in the secondary state, he told her that she (the secondary personality) was to solve an arithmetical problem, the general nature of which he described to her then and there, while the actual numbers were not shown till she was put back in the primary state. He then put her into the primary state for a few moments, and placed the numbers unobtrusively before her, without the primary personality seeming to notice them. Put back now into the secondary state, she instantly shouted out the answer to the problem, and asserted that she (the secondary personality) had had the answer ready for some time, and had been impatiently waiting to be brought back and announce it. This is at least prima facie evidence in favor of Dr. Prince's view,

that two separate fractions of the individual were both acting consciously at the same time.

It is weird business, however interpreted, and raises the question whether anything of the same sort, only milder in degree, occurs in ordinary experience. Here is one somewhat similar fact that we are all familiar with: we have two matters in hand at the same time, very different in their emotional tone, one perhaps a worrisome matter of business, the other an interesting personal matter; and the shift from one to the other feels almost like changing personalities. Also, while busy with one, we may sometimes feel the other stirring, just barely awake and dimly conscious.

Also, is not something like this true?—A person, very conscientious in the performance of his duties, always doing what he is told, feels stirrings of a carefree, independent spirit, as if some sides of his nature were not finding expression, and in little ways he gives it expression, not exactly by taking a "moral holiday" [19] or going on a spree of some sort, but by venting his impulses just an instant at a time, so that he scarcely remembers it later, and in such little ways that other people, also, are scarcely aware of it. He has a "secondary personality," only it is little developed, and it has its little place in the conscious life, instead of being dissociated.

In the cases of true dissociation, there was often a violent emotional shock that started the cleavage. One celebrated case started at 3 years of age, when the subject, a little girl, was thrown to the floor by a drunken father angered by finding the child asleep in his bed. From that moment, it would seem that the frolicsome side of childish behavior was banished from the main personality, and could get into action only when the main personality relaxed its control and became dormant; so that thereafter the child alternated between two states, one very quiet, industrious and conscientious, the other vivacious

[19] This is one of William James's expressive phrases.

and mischievous; and the main personality never remembered what was done in this secondary, mischievous state. In such cases, it would appear that the cleavage resulted from a sudden intensification of the serious side of the child's life, and a violent thrusting aside of normal inclinations for playful and mischievous behavior.

THE UNCONSCIOUS, OR, THE SUBCONSCIOUS MIND

Here at last, it may strike the reader, we have come to the core of the whole subject of psychology; for many readers will undoubtedly have been attracted by the statements sometimes made, to the effect that the "unconscious" represents the deeper and more significant part of mental life. There is a sort of fascination about the notion of a subconscious mind, and yet it will be noticed that psychologists, as a rule, are inclined to be wary and critical in dealing with it. Let us take up in order the various sorts of unconscious mental processes.

In the first place, *retention is unconscious.* The host of memories that a person possesses and can recall under suitable conditions is carried about with him in an unconscious condition. But there need be no special mystery about this, nor is it just to speak about memories being "preserved in the unconscious." The fact simply is that retention is a resting condition, whereas consciousness is an active condition. Retention is a matter of brain structure, neurone connections, neural mechanisms ready for action when the proper stimulus reaches them but remaining inactive till the stimulus comes. An idea is like a motor reaction, to the extent that it is a reaction; and we retain ideas in the same way that we retain learned motor reactions. Now no one would think of saying that a learned motor reaction was retained in the unconscious. The motor reaction is not present at all, until it is aroused; the neuromuscular mechanism for executing the reaction is present, but

needs a stimulus to make it active and give the reaction. In the same way, an idea is not present in the individual except when it is activated, but its neural mechanism is present, and unconscious just because it is inactive.

Unconscious inactivity is therefore no great problem. But there is such a thing as *unconscious activity*. Two sorts of such activity are well known. First, there are the purely "physiological" processes of digestion, liver and kidney secretion, etc. We are quite reconciled to these being unconscious, and this is not the sort of unconscious activity that gives us that fascinatingly uncanny feeling. Second, there are the "secondarily automatic" processes, once conscious, now almost or quite unconscious through the effect of frequent repetition.

Such unconscious activities occur as *side-activities,* carried on while something else occupies attention, or as *part-activities* that go on while attention is directed to the total performance of which they are parts. In either case, the automatism may be motor or perceptive, and the degree of consciousness may range from moderate down to zero.[20]

For example, the letters of your name you write almost unconsciously, while fully conscious of writing your name. When you are reading, the letters are only dimly conscious, and even the words are only moderately conscious, while the whole performance of reading is highly conscious. These are instances of unconscious (or dimly conscious) part-activities. Unconscious side-activities are illustrated by holding your books firmly but unconsciously under your arm, while absorbed in conversation, by drumming with your fingers while puzzling over a problem, and by looking at your watch and reading the time, but so nearly unconsciously that the next instant you have to look again. In all such cases, the unconscious or barely conscious activity has been made easy by previous practice, and there is no special fascination about it,

[20] See pages 126, 378.

except such as comes through the use of that awesome word, "unconscious."

But now for the real "subconscious mind." You try to recall a familiar name, but are stuck; you drop the matter, and "let your subconscious mind work"; and, sure enough, after a few minutes you have the name. Or, you are all tangled up in a difficult problem; you let the subconscious mind work on it overnight, and next morning it is perfectly clear. Just here it is that psychology begins to take issue with the popular idea. The popular interpretation is that work has been done on the problem during the interval when it was out of consciousness — unconscious mental work of a high order. But is it necessary to suppose that any work has been done on the problem during the interval?

The difficulty, when you first attacked the problem, arose from false clues which, once they got you, held you by virtue of their "recency value."[21] The matter laid aside, these false clues lost their recency value with lapse of time, so that when you took the matter up again you were free from their interference and had a good chance to go straight towards the goal.

It is the same with motor acts. On a certain day, a baseball pitcher falls into an inefficient way of handling the ball, and, try as he may, cannot recover his usual form. He has to give up for that day, but after a rest is as good as ever. Shall we say that his subconscious mind has been practising pitching during the rest interval? It is much more likely that here, as in the preceding case, the value of a fresh start lies in freshness, and the consequent disappearance of interferences, rather than in any work that has been done during the interval of rest.

Consider, however, the "co-conscious," as Morton Prince has named the presence and activity of the secondary personality along with the primary, as in his experiment described above.

[21] See pages 98, 428.

Here it does seem that two conscious activities were flowing along side by side within the same individual. There is the activity of the main personality, and there is the activity of the secondary personality, going on at the same time without the knowledge of the main personality. This is a way of reading the facts, rather than a simple statement of fact, but at least it is a reasonable interpretation, and worthy of consideration.

UNCONSCIOUS WISHES AND MOTIVES

Schopenhauer wrote much of the " will to live," which was, in his view, as unconscious as it was fundamental, and only secondarily gave rise to the conscious life of sensations and ideas. Bergson's " élan vital " has much the same meaning. In a sense, the will to live is the fountain of all our wishes; in another sense, it is the sum total of them all; and in another sense, it is an abstraction, the concrete facts consisting in the various particular wishes and tendencies of living creatures. The will to live is not simply the will to stay alive; it is the will to *live,* with all that that includes. Life is activity, and to live means, for any species, to engage in the full activity possible for that species.

The will to live is in a sense unconscious, since it is seldom present simply in that bald, abstract form. But since life is activity, any will to act is the will to live in a special form, so that we may perfectly well say that the will to live is always conscious whenever there is any conscious impulse or purpose.

In this simple statement we may find the key to all unconscious motives, disregarding the case of dissociation and split personality. If you analyze your motive for doing a certain act and formulate it in good set terms, then you have to admit that this motive was unconscious before, or only dimly conscious, since it was not formulated, it was not isolated, it was not present in the precise form you have now given it. Yet

it was there, bound up in the total activity. It was not unconscious in the sense of being active in a different, unconscious realm. The realm in which it was active was that of conscious activity, and it formed an unanalyzed part of that activity. It was there in the same way that overtones are present in the tone quality of a particular instrument; the overtones are not *separately* heard and may be very difficult to analyze, yet all the time they are playing an important part in the conscious perception.

In the same way, we may not "realize" that we are helping our friend as a way of dominating over him, but think, so far as we stop to think, that our motive is pure helpfulness. Later, analyzing our motives, we may separate out a masterful tendency, which was present all the time and consciously present, but so bound up with the other motive of helpfulness that it did not attract attention to itself. Now if our psychology makes us cynics, and leads us to ascribe the whole motivation of the helpful act to the mastery impulse, and therefore to regard this as working in the unconscious, we are fully as far from the truth as when we uncritically assumed that helpfulness was the only motive operating.

For man, to live means a vast range of activity — more than can possibly be performed by any single individual. We wish to do a thousand things that we never can do. We are constantly forced to limit the field of our activity. Physical incapacity, mental incapacity, limitations of our environment, conflict between one wish and another of our own, opposition from other people, and mere lack of time, compel us to give up many of our wishes. Innumerable wishes must be laid aside, and some, resisting, have to be forcibly suppressed. Renunciation is the order of the day, from childhood up to the age when weakness and weariness supervene upon the zest for action, and the will to live fades out into readiness to die.

What becomes of the suppressed wishes, we have already

briefly considered.[22] We have noticed Freud's conception that they live on " in the unconscious." Each one of us, according to this view, carries around inside of him enough explosive material to blow to bits the whole social structure in which he lives. It is the suppressed sex wishes, and spite wishes growing out of thwarted sex wishes, that mostly constitute the unconscious.

These unconscious wishes, according to Freud, motivate our dreams, our queer and apparently accidental actions, such as slips of the tongue and other " mistakes," the yet queerer and much more serious " neurotic symptoms " that appear in some people, and even a vast deal of our serious endeavor in life. All the great springs of action are sought in the unconscious.

Freud's conception of life and its tendencies is much too narrow. There is not half enough room in his scheme of things for life as it is willed and lived. Any scheme of motivation, which traces all behavior back to a few formulated wishes, is much too abstract, as was illustrated just above in the case of the helpful act.

Freud is apparently guilty of yet another error, in supposing that any specific wish, ungratified, lives on as the same, identical, precise wish. A very simple instance will make clear the point of this criticism. Suppose that the first time you definitely mastered the fact that " 3 times 7 are 21," it was in a certain schoolroom, with a certain teacher and a certain group of schoolfellows. You were perhaps animated at that moment by the desire to secure the approval of that teacher and to shine before those schoolfellows. Does it follow, then, that every time you now make use of that bit of the multiplication table, you are " unconsciously " gratifying that wish of long ago? That wish of long ago played its part in linking the response to the stimulus, but the linkage became so close that that precise wish was no longer required. The same re-

[22] See pages 271, 484.

sponse has been made a thousand times since, with other wishes in the game, and when the response is made to-day, a new wish is in the game.

In making use of the conception of the unconscious to assist us in interpreting human conduct, we are thus exposed to two errors. First, finding a motive which was not analyzed out by the individual, and which was only vaguely and implicitly conscious, and formulating that motive in an explicit way, we are then liable to the error of supposing that the motive must have been explicitly present, not indeed in consciousness but in the unconscious; whereas the whole truth is exhausted when we say that it was consciously but only implicitly present — active, but not active all alone. Second, having traced out how a certain act was learned, we are apt to suppose that its history is repeated whenever it is performed afresh — that the wishes and ideas that were essential to its original performance must be unconsciously present whenever it is once more performed — neglecting thus the fact that what is retained and renewed consists of responses, rather than experiences. What is renewed when a learned act is performed is not the history of the act, but the act itself. In a new situation, the act is part of a new performance, and its motivation is to some degree new.

The positive value of the concept of the unconscious, if it is properly understood and not conceived as an entity or separate sphere of behavior, lies in its emphasis on two important facts that have been brought out in the preceding discussion. It is important to recognize that the roots of present behavior extend far back into the individual's past, and that the experiences, conflicts and adjustments which still have their effects in the present have often been forgotten. And it is important to recognize behavior and personality as an integrated whole, containing unanalyzed motives that are not clearly conscious just because bound up in the integrated total.

EXERCISES

1. Can you trace any effects of a beautiful face upon the owner's social behavior and personality?

2. Discuss this proposition: that, as personality is an integration of the whole individual, no single handicap can prevent the development of a first-class personality.

3. Work out the antithesis between good judgment and suggestibility.

4. Make a study of some difficult adjustment that you have observed in your own case or in that of some one else.

5. Analyze the adjustments which the subject in our case history in the first chapter had to make.

6. What personal traits seem to remain about the same from childhood to old age, and what ones seem to change with the age of the individual?

7. Apply the principles of our discussion of Heredity and Environment to the question of personality development.

8. What is helpful and what misleading in the systems of psychological types that have been proposed?

9. What do you find useful and what confusing in the concept of the unconscious?

10. Free association test for students of psychology. Respond to each of the following stimulus words by the first word suggested by it of a psychological character:

conditioned	cerebellum	suffering
level	constancy	controlled
inference	mirror	tension
delayed	binaural	blend
introspective	pyramidal	rod
thyroid	semicircular	interstitial
stimulus	kinesthetic	fovea
axon	advantage	saturated
co-conscious	field	inferiority
race	quotient	fallacy
synapse	limit	complementary
autonomic	interbrain	after

retention
egocentric
amnesia
aphasia
agnosia
apraxia
nonsense
higher
adrenal
autistic
visualist
paired
economy
exploration
recency
distribution
perseveration
synesthesia
facilitation
correlation
end-brush
case
heredity
moron
rationalize
animistic

organic
preparatory
endocrine
expressive
foster
anthropoid
trial
monster
maturation
timbre
figure
similarity
extrovert
arc
flexion
mastery
feeling
empathy
reduced
censor
all or none
transfer
set
sign
shifting
pupillary

shut-in
span
retroactive
eidetic
pursuit
receptor
pituitary
extinction
recitation
manic
basilar
fluctuation
spaced
atrophy
frontal
overlapping
adjustment
Binet
Weber
Wundt
James
Lloyd Morgan
S
R
O
G

INDEX